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GROUNDWARS 5.3 USER'S GUIDE

MARCH 1995

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13. ABSTRACT *(Maximum 200 words)*

Groundwars is a stochastic, two-sided, event-sequenced computer simulation which provides the results of a land duel between two forces. It models attacker movement and intervisibility based upon statistics from digitized terrain and intermittent obscurants. Groundwars models individual weapon systems and employs Monte Carlo probability theory as its solution technique. The model is primarily used to evalute weapon system effectiveness. Groundwars can address ammunition expenditures, acquisition, delivery accuracy, vulnerability, lethality, rate of fire disengagement policies, effect of line-of-sight due to terrain or obscurants, and the effect of various weapon classes. Version 5.3 incorporates new methodology to include wide and narrow field of view target acquisition, capability draw for NVESD P-Infinity, Javelin weapon system lock-on-before-launch, ranging-in, burst-fire delivery accuracy changes, hunter-killer, communication, and new MOEs.

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Groundwars 5.3
User's Guide

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1 Introduction

1.1 Model Overview

- **Background**

  Groundwars is a weapon systems effectiveness combat simulation model which provides the results of a land duel between two forces. The model simulates battle at the individual weapon system level and employs Monte Carlo probability theory as its primary solution technique. The simulation is stochastic and event sequenced.

  Groundwars is an outgrowth of the TANKWARS model, version II, written in the mid 1980s by Fred Bunn of the Army Research Laboratory (ARL), Aberdeen Proving Ground, Maryland.[1] The original model has been modified by AMSAA over the years to include numerous enhancements and new methodologies. As the AMSAA version grew and evolved, it was renamed Groundwars. The current version of the model is Groundwars Version 5.3.

- **Platforms**

  A total of 6 different platform types can be deployed between the two forces. The user determines the size of the two forces (maximum of 100 total systems), the weapon mix and performance data, the range at which the battle will begin, the attack angle distribution to be used, the terrain statistics to be used, and the atmospheric conditions. Each platform is assigned one weapon type for use throughout the battle.

- **Terrain**

  Intervisibility between combatants is determined by statistical terrain data. This allows investigation of situations on a general area of terrain. One concern about results from combat simulations is that they are specific to the area of ground on which the scenario is set and to the deployment and tactics used by both sides; the conclusions which are drawn from such results may or may not be generally applicable. This, of course, can be overcome by changing the tactics, deployments, and ground; but the time implications of such a study are generally unacceptable. A statistical terrain, although developed from a set (or sets) of defender locations and attacker routes with accompanying line-of-sight (LOS) arrangements, is sampled independently for LOS opportunities during the battle and for subsequent replications, and utimately provides a representation of the terrain's LOS opportunities. A statistical terrain model is used to generate the lines of sight which occur during the battle from empirical data, field trials, and other sources. Since data from such sources are combined across different cases in which the ground, the tactics, and therefore deployments may all be changed, the results obtained from the simulation are not restricted to a specific arrangement of forces on the area of the terrain; thus the results from Groundwars are applicable to a general type of combat (e.g., the assault of a well-prepared position) and so provide a basis for screening a large number of cases or scenarios prior to modeling a select few in more detail in a higher-level model.

  Four terrain distributions are incorporated into the model, representing probabilities of in-view and out-of-view LOS segments between individual defenders and groups of attackers. They can be selected by the user without requiring specific distributions to be input; they are *Eschenbach, Hunfeld, Peine (Germany),* and *Al Mafraq (SWA)* (Tables 1 and 2). Eschenbach has choppy terrain with limited opening range and in-view lengths. Hunfeld has moderate ranges. Peine is flat and has long opening range and in-view lengths. Al Mafraq has even longer in-view lengths. *Table-top* terrain, in which defenders and attackers always have LOS, can also be chosen. The model also allows the user to input other terrain distributions if desired. Vehicles in overwatch and defenders always have line-of-sight to one another.

[1] F. Bunn, "THE SUSTAINED COMBAT MODEL: TANK WARS II, An Armored Combat Analysis Program," BRL Technical Report ARBRL-TR-09999, December 1985.

Table 1: **Opening LOS Range Distributions**

Opening LOS Range (Range at First LOS)			
Eschenbach		Hunfeld	
Range (M)	Probability	Range (M)	Probability
0	.000	0	.000
1000	.113	1000	.073
2000	.444	2000	.290
3000	.709	3000	.619
4000	.803	4000	.866
5000	.926	5000	.950
6000	.962	6000	.985
7000	1.000	7000	.993
		8000	.999
		9000	1.000
Peine		Al Mafraq	
Range (M)	Probability	Range (M)	Probability
0	.000	0	.000
1000	.000	500	.005
2000	.055	1000	.020
3000	.317	1500	.025
4000	.660	2000	.040
5000	.836	2500	.120
6000	.917	3000	.220
7000	.965	3500	.310
8000	1.000	4000	.390
		4500	.540
		5000	1.000

Table 2: **LOS Probability Distributions**

In-LOS and Out-of-LOS Probability Distribution					
Eschenbach			Hunfeld		
Range (M)	In	Out	Range (M)	In	Out
0	.000	.000	0	.000	.000
100	.211	.117	100	.158	.141
200	.370	.186	200	.280	.239
300	.513	.247	300	.379	.320
400	.617	.308	400	.469	.380
500	.703	.369	500	.543	.441
600	.767	.414	600	.589	.485
700	.815	.458	700	.638	.518
800	.853	.495	800	.669	.544
900	.878	.522	900	.705	.567
1000	.898	.543	1000	.740	.588
1500	.954	.653	1500	.871	.671
2000	.981	.744	2000	.950	.747
2500	.994	.791	2500	.979	.796
3000	.997	.861	3000	.993	.846
3500	.999	.902	3500	.997	.879
4000	1.000	.929	4000	.999	.915
4500	1.000	.942	4500	.999	.936
5000	1.000	1.000	5000	1.000	1.000
Peine			Al Mafraq		
Range (M)	In	Out	Range (M)	In	Out
0	.000	.000	0	.00	.00
100	.118	.136	500	.59	.61
200	.188	.209	1000	.77	.76
300	.245	.274	1500	.86	.84
400	.295	.336	2000	.92	.89
500	.340	.349	2500	.96	.92
600	.379	.417	3000	.98	.95
700	.417	.444	3500	1.00	.97
800	.442	.470	4000	1.00	.98
900	.471	.488	4500	1.00	.99
1000	.499	.507	5000	1.00	1.00
1500	.648	.615			
2000	.742	.685			
2500	.828	.744			
3000	.868	.793			
3500	.908	.824			
4000	.935	.835			
4500	.947	.852			
5000	1.000	1.000			

- **Acquisition**

  Given that intervisibility exists between two combatants, acquisition may occur. An observer may acquire a target either by normal search or by detection of the target's firing signature. Normal acquisition is based on the *Night Vision Electronic Sensors Directorate (NVESD)* target detection routines, and is a function of the sensor, the atmosphere, the target, and range. An observer may also detect a target's firing signature. Whenever an enemy system fires, there is a probability that the observer will detect it. If this probability is met, the observer begins engagement of the target after a random period of time which is sampled from a distribution generated from test data.

- **Weapons**

  Four types of rounds can be played in the model: ***kinetic energy (KE), high explosive anti-tank (HEAT), anti-tank guided missiles (ATGM),*** and ***fire and forget missiles (FAF).*** For each weapon the model requires system characteristics (firing times, times of flight, reliability), accuracy data, and vulnerability data.

- **Target Engagement**

  Three types of target engagements can be played in the model. The first is single target engagement in which a firer detects a target, begins engagement of the target, and discontinues all other actions. The second type allows the firer to detect a target and begin engaging, and to concurrently search for additional targets. Once the firer disengages the first target, he will select the next target from his list and begin engaging the next target. The third type of engagement can only be played with fire and forget missiles. In this type of engagement, the firer attempts to queue a number of targets, and then fire a single shot at each of the queued targets nearly simultaneously.

- **Countermeasures**

  A number of countermeasures can be simulated. These include smoke grenades, laser warning receivers (LWR), an Active Protection System (APS), and artillery-delivered smoke. When an on-board grenade system detects an incoming round, it can launch grenades around the vehicle and form a cloud of smoke which may cause incoming missiles to abort. An APS can sense an incoming round and either destroy, jam, or degrade an incoming projectile. The user may control the level of effectiveness for these self-defense systems. Artillery delivered smoke can also be played on the battlefield to degrade acquisition capabilities.

- **Artillery**

  Limited artillery play is also implemented in the model. Each side can deploy one on-call mission during a battle, and the attacking force is given the option to have one preparatory artillery barrage. For each type of mission, there is an associated probability of kill which is assessed against enemy vehicles. On-call artillery missions occur at random times in the battle.

- **Disengagement**

  Groundwars allows the user to choose from two optional disengagement tactics. A firer will always disengage a target after the target is catastrophically killed. One optional tactic is to disengage a target after hitting it. Another is to fire a certain number of rounds at a target and then disengage. For these optional tactics, the model allows a firer to return to a serviced target if he hasn't found another target after a period of time.

- **MOEs**

  The primary measures of effectiveness for the simulation are loss exchange ratio, mean casualties, system exchange ratios, and average losses as a function of time in the battle. The secondary measures include surviving force ratio, shots, hits, and kills for each weapon-target pairing, and average detections by each sensor. The amount of output is directly controlled by the user, and can range from averages to a detailed break down of many facets of the battle.

- **Uses**

  Groundwars can provide a trade-off analysis between major weapon system characteristics such as fire control, vulnerability, and accuracy. It can provide analysis for a number of combat related issues (i.e. terrain, atmospheric conditions, attack angles). The effects of changes in target acquisition, target disengagement policy, and ammunition storage can be shown relatively quickly and easily.

- **Limitations**

  Model limitations include no modeling of suppression, and an emphasis on direct-fire weapon systems only. Groundwars also does not play helicopters or mines, nor does it include a dismounted infantry submodel. In addition, only one weapon system per platform is modelled.

- **Runtime**

  A major attribute of Groundwars is its quick set-up and run time which allows for examination of many situations and conditions. The model provides a basis for modeling system interactions and can enable an analyst to obtain a good understanding of these effects prior to large scale combined arms modeling.

1.2 What's new in Version 5.3

A number of enhancements have been made to Groundwars since version 5.0, to include improved methodologies, new weapon system capabilities, and some bug fixes. The following list provides an overview of these changes:

- **Capability Draw** - Based on the recommendations of the the AMSAA/TRAC-WSMR Joint Working Group on Methodologies in Combat Simulation Models, the P-Infinity *Capability Draw* methodology was recently implemented in the Groundwars model, replacing the older *Opportunity Draw* methodology.

  The NVESD (Night Vision Electronic Sensors Directorate) target detection algorithms used in Groundwars calculate *P-Infinity* and *T-Bar* (mean time to detect) based upon sensor, atmospheric conditions, and target characteristics. *P-Infinity* can be defined as the probability of detection given an infinite amount of time.

  In Groundwars, upon opening line-of-sight, acquisition capability is determined by drawing a uniform [0,1] random number and comparing it to the calculated P-Infinity. If the random number is less than P-Infinity, the target can be detected by the observer, and a time to detect is calculated based upon the value of T-Bar.

  The *Opportunity Draw* methodology consisted of testing a new random number draw against the value of P-Infinity for every opportunity (i.e., new line-of-sight opening between observer and target). It is felt that this method misuses the P-Infinity probability by repeatedly drawing random numbers until, in effect, the P-Infinity test succeeds.

  The *Capability Draw* consists of drawing a uniform[0,1] random number at the beginning of the replication for each observer and assigning it to that observer for the duration of the battle. The observer's random number is used for all P-Infinity tests for that observer for the duration of the battle.

- **Wide and Narrow Field-of-View (FOV) Search** - Changes were implemented to simulate the play of both wide FOV (WFOV) and narrow FOV (NFOV) search; that is, to simulate an observer searching for targets in WFOV, and, when a target is WFOV-acquired, the observer switching to NFOV and attempting to find the target in NFOV. Previously, Groundwars allowed only one FOV for search and engagement.

- **Ranging-In** - *Ranging-in* is a process used by gunners to adjust fire on the target. The range-in process lowers accuracy errors for weapon systems with limited fire control since the gunner must correct for errors associated with target range estimation, system biases, etc. The gunner achieves more accurate fire by adjusting the aimpoint in response to the perceived impact location of the preceding round. Groundwars now allows ranging-in to be simulated for burst-fire weapons.

- **Javelin** - Groundwars can now simulate a lock-on-before-launch system like *Javelin*. See the *Weapon Input File* descriptions for further information.

- **Burst-Fire** - Fixes to the burst fire code now allow separate burst-fire rounds to be simulated, as well as adding the capability to input a different variable bias for subsequent burst delivery accuracy. Also, ranging-in capability has been added as described above.

- **Hunter-Killer** - Groundwars allows simulation of the ***Hunter-Killer*** capability by allowing a system to detect up to an input specified number of targets concurrently, simulating the effect of a gunner engaging one target while a commander continues to search for another. Previously, Groundwars only modeled one FOV capability for the search and engagement process, and the first acquired target was passed immediately to the gunner for engagement while the commander then continued searching. With the new wide and narrow FOV search in Groundwars, Hunter-Killer is modeled by having the commander acquire a target in WFOV, then pass this information to the gunner, who then proceeds to search, re-acquire, and engage for the target in NFOV. Meanwhile, the commander can search in WFOV for another target.

- **Communication** - In Groundwars, this refers to inter-vehicular communication, i.e., communication among vehicles on the same force for the purposes of sharing target location information (not situational awareness). With the new wide and narrow FOV capability in the model, communication is modeled as follows: When an observer acquires a target in WFOV, the observer transmits the target location to all other friendly systems. The original observer and all receiving systems will then attempt to acquire the target in NFOV before proceeding to engage. (Note: The only way to govern the distribution of fire once the information is passed is to increase or decrease the time to wait (input variable described below) before the receiving vehicle will react.) One set of values per force for the following is input and applied to each unit in that force for the following:

  - probability of receiving a transmission of target location,
  - time to wait before the receiving vehicle will conduct its field-of-view search, and
  - length of time the receiving vehicle will search in its field-of-view before renewing normal search.

- **Active Protection System (APS)** - Degradation factors (affecting lethality of incoming rounds) may now be input by range (from firer to target with APS) and by vehicle exposure (hull defilade or fully exposed).

- **Attack Angle Distributions** - Some errors in the third decimal place have been corrected.

- **Terrain** - An additional statistical terrain is now user-selectable within the model. It is *Al Mafraq*, a Southwest Asia terrain with very long lines-of-sight.

- **Rounds Consumed Per Enemy System Killed** - A new Measure of Effectiveness has been added to Groundwars. ***Rounds Consumed per Enemy System Killed*** is now included in the model. This MOE is a measure of rounds-fired plus rounds-stowed-that-are-lost- when-a-system-is-K-Killed divided by enemy-systems-killed. The MOE is reported by platform type.

- **Radar** - A correction to the radar acquisition routine was made which affects the calculation of the signal-to-noise ratio.

- **Debug Flags** - Three more debug flags (to total 33) have been added to handle *NFOV-acquisition, lock-on-before-launch,* and *Range-in* events.

- **Bug Fixes** - A number of rare but annoying run-time errors have been tracked down and fixed involving the *disengagement*, *target selection*, *print acquisition*, *acceleration*, and *deceleration* routines.

1.3 Future Modifications

As is typical with computer simulation models, Groundwars is an evolving entity. Bugs are discovered and corrected. New, and hopefully better, methodologies replace older ones, and enhancements are made to simulate new technologies and weapon systems. Modifications are also made in order to better represent the combined arms battlefield. Whatever direction Groundwars takes in the future, it remains our aim to retain the current level of resolution and methodology at which Groundwars models critical battlefield events. By trying to keep embedded engineering calculations to a minimum, and requiring most input data to be in the form of probabilities, Groundwars can continue to run quickly, require a modest amount of set-up time, and be more easily modified to simulate new weapon technologies. Further, the use of statistical terrain, besides the inherent benefit of generality, keeps the model run-time short and allows hundreds of replications to be run in minutes.

The following modifications to Groundwars are planned for implementation in early 1995:

- Multiple Weapons per Platform - This allows a vehicle to fire up to three weapon types (e.g., firing a missile at long range, a cannon round at medium range, and a machine gun at close range).

- Non-Line-of-Sight (Phase I) - This is to model the firing of a round when Line of Sight (LOS) is lost after acquisition, but before firing the first round (e.g., STAFF).

The following items comprise our current list of possible future modifications to Groundwars. These modifications are dependent on future requirements for Groundwars and may or may not be implemented, depending on the need, the time, and the appropriateness.

- Multiple sensors per platform
- Geometry (More explicit representation of terrain coordinates)
- Dismounted Infantry
- Improved Pinpoint (Flash Signature Target Acquisition) methodology
- Mines and other barriers
- Graphical output / playback
- Helicopters

2 Input Data Requirements

The program has been released with certain limits on the number of units in a battle (100) and the number of different vehicle, weapon and sensor types which can be played (6). These limits may be modified and the model recompiled, but some additional modifications may be needed within the program to achieve this.

Groundwars requires a number of input files. There is a *game* control file in which the user determines the scenario, the terrain, and the level of output desired. This file also determines the attack angle distribution, the visibility conditions, etc.

For each army there is a *unit* deployment file in which the number of units, the starting locations of the units, and the function of the units in the battle is set. An *army* information file describes force characteristics such as disengagement tactic, artillery lethality, and decoys for each army. Each side has a file which describes its *vehicles*, one for its *weapons*, and one for its *sensors*. For each weapon system there is an *accuracy* file, and for each weapon-target pair there may be a *vulnerability* file. If artillery delivered smoke or other obscurants are to be played, a file is required to characterize the periods and levels of *obscuration*. If fratricide and combat identification (CID) are played, additional files are required which describe *engagement* rules and *CID* effectiveness.

All files except the Individual Unit Action (IUA) vulnerability files are free formatted. Comment lines may be added to the TOP of any input files by starting the line with an asterisk (*). Any lines shown in the documentation are there for clarity and the program expects them to be there. They may be changed, but cannot be deleted. Data which are entered as character strings can be a maximum of seven letters long and can include capital or small letters (longer strings will be truncated to seven letters). All times which are entered into the data files are in seconds, and all linear measurements (dimensions, speed, etc.) are in meters.

The program searches for all of its input files in the current working directory. All input files which are needed for the battle must be assembled into the current directory prior to execution of the program. The program requires input files with specific names. These names will be explained in the specific input sections.

2.1 Game File

This file defines the scenario to be played and controls the level of output. The file must be named *game* in the current working directory for the program to read it. The general structure of the file is shown in Table 3. Tables 4 through 6 list Game File input variable definitions. Table 8 shows a sample game file. Table 9 lists output control flag options. Table 10 shows the input structure of user defined terrain input data.

Table 3: **Game File**

Line	
0	** Comment Line(s)
1	Scenario: RED Attack, BLUE Attack, STATIONARY Engagement
2	Terrain: Eschenbach, Hunfeld, Peine, Al Mafraq, Table-top, Other
3	Attack Angle Distribution: Cardioid, Frontal, CV-CPOA, Close Combat
4	Atmospheric Visibility Range, Optical Attenuation, Thermal Attenuation
5	Output Control Flags (7)
6	Program Debug Flags (33)
7	Range Increment for Input
8	Maximum Battle Time in Seconds
9	Increments for Output Tables: Time, Range
10	Maximum Number of Replications, Initial Random Seed
11	Pinpoint Restriction Flag
12	Statistical Confidence Level, Relative Width
13+	User specified terrain distributions (only input if "Other" on line 2)

Table 4: **Game File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Scenario	Type of Engagement (Character String) [RED Attack, BLUE Attack, STATIONARY Engagement]
2	Terrain	Statistical terrain distribution for the model to use to generate line-of-sight during play *[Eschenbach, Hunfeld, Peine, Al Mafraq, Table-top, Other]*. If "Other" is selected, the user must input additional lines describing the user-specified terrain. See line 13+ description below for further information. (Character String)
3	Attack Angle Dist	Identification of what distribution is to be used when sampling to determine the angle of impact in the horizontal plane for an incoming round (Character String). See Table 7 for a list of the available distributions. *[Cardioid, Frontal, CV-CPOA, Close Combat]*.
4	Vis Range	Atmospheric Visibility Range in km. Used along with other input to determine target acquisition capabilities during the battle.
	Optical Atten	The corresponding atmospheric attenuation coefficient for optical transmission.
	Thermal Atten	The corresponding atmospheric attenuation coefficient for thermal transmission.
5	OFlags	Output Control Flags. These seven integers determine the detail and amount of output generated for a battle. If all flags are set to zero, only the summary statistics representing the averages of the replications run for the case will be listed. The output generated by setting flags to non-zero values are shown in table 9. For example, setting flag two to the value of one or two causes an echo of some of the weapon system characteristics inputs to help the user check for input errors. Analysis of acquisition capabilities can be aided by listing acquisition probabilities and time estimates as a function of range for each sensor/target pairing (flag three).
6	DFlags	Program Debug Flags. This line contains 33 flags which enable printing of many variable values as the model executes. These are intended for debugging purposes. They should not be set greater than zero for more than one replication, as they produce a lot of output.

Table 5: **Game File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
7	Rginc-In	Range Increment for Input. When range-dependent data are read in other input files, the ranges used must be in increments of this variable. Examples are vulnerability data, accuracy, and firing times. Increment is in meters.
8	Max Time	Maximum Battle Time in Seconds. This time will be used to end the battle unless all combatants on one side are dead or non-functioning. Note: When playing an attack/defense scenario, do not input a maximum battle time which allows the attacking force to over run the defenders, and continue past them. This will probably cause a runtime error. (The attacking force's movement rate is input in the vehicle file. Each army's initial deployment location is input in their respective unit deployment files.)
9	Time Inc	Increments for Output Tables by Time. This variable allows the user to control the output of certain measures of effectiveness which are recorded and reported as a function of time (sec). Included MOEs are average RED and BLUE losses and exchange ratio.
	Rginc-Out	Increments for Output Tables by Range. This variable allows the user to control the output of certain measures of effectiveness which are recorded and reported as a fuction of range (in meters). Included MOEs are acquisitions, shots, hits, and kills.
10	Max Reps	Maximum Number of Replications. Since Groundwars is a monte carlo model, a number of replications must be run to achieve a certain level of confidence in the output (see line 12 below). Typically, 300 to 500 replications are sufficient for most studies, depending on the total number of combatants played. This input number of replications will be used only if the desired level of statistical confidence has not been reached by this point (see line 12 below).
	Ran Seed	Initial Random Seed. An integer is needed for use as a seed for Groundwars' random number generator. For example, 12345678.

Table 6: **Game File Input Definitions - Continued (2)**

LINE	VARIABLE	DEFINITION
11	Pinp RFlag	Pinpoint Restriction Flag. The ability of an observer to detect a target's firing signature (pinpoint) can be restricted by this input. Setting this flag to zero allows observers to detect firing signatures regardless of their ability to detect the same target (given its range, etc.) by normal search. Setting the flag to a value of one restricts the observers' ability to pinpoint a target to those situations in which the calculated value of P-Infinity (based on the sensor, target, atmosphere, and current range) is greater than zero.
12	Conf Level	Statistical Confidence Level. This is for the desired confidence level for the output RED and BLUE dead, and Exchange Ratio. Along with the next input, relative width, they are used to terminate the simulation if the desired level of confidence has been reached. The model records the results from each of the replications and calculates the mean and standard deviation for all preceding replications. If the results meet the statistical criteria which the user sets for all three of the above measures of effectiveness the model terminates execution. The user specifies the level of confidence (80.,90.,95., 98.,or 99.) and the relative width (see below).
	Relative Width	Specifies the desired coverage of the calculated mean with respect to the true mean of the distribution. Usually between .05 and .15. For example, if the user specified 95 percent confidence and a .05 for the relative width, then one can be 95 percent confident that the true mean of the distribution is within 5 percent of the displayed mean.
13+	[User Terr Dist]	Only input if "Other" is specified on line 2. If a user defined terrain is being used, an additional section to the file must be input here. For intervisibility, the model first finds the range at which line of sight first opens; this occurrence is characterized by the first opening range distribution. Once the initial opening range is found, the model draws alternating in and out of view segments of varying lengths. The lengths of these segments are drawn from two additional distributions. The format for entering the three distributions, first opening range, in-view segment lengths, and out of view segment lengths, is shown in Table 10. Note the probability distributions are cumulative and the values for the longest ranges must be 1.0.

Table 7: **Attack Angle Distributions**

Cardioid		Frontal		Close Combat		CV-CPOA	
Angle	Prob	Angle	Prob	Angle	Prob	Angle	Prob
0.	.0000	0.	.0000	0.	.0000	0.	.0000
25.	.1365	15.	.2925	15.	.1250	15.	.1815
45.	.2370	45.	.4650	45.	.1900	45.	.3040
75.	.3620	75.	.4925	75.	.2350	75.	.3790
105.	.4460	105.	.5000	105.	.3650	105.	.4525
135.	.4880	255.	.5000	135.	.4100	135.	.4810
165.	.5000	285.	.5075	165.	.4650	165.	.4945
180.	.5000	315.	.5350	180.	.5000	180.	.5000
195.	.5000	345.	.7075	195.	.5350	195.	.5055
225.	.5120	360.	1.0000	225.	.5900	225.	.5190
255.	.5540			255.	.6350	255.	.5475
285.	.6380			285.	.7650	285.	.6210
315.	.7630			315.	.8100	315.	.6960
335.	.8635			345.	.8750	345.	.8185
360.	1.0000			360.	1.0000	360.	1.0000

Table 8: **Game File Sample**

```
** Sample Game File
red attack              *scenario description
Peine                   *terrain specification
cv-cpoa                 *attack distribution
7.0 .69 .42             *visibility range, optical, and thermal attenuations
1 0 2 0 0 1 0           *output control flags
33*0                    *debug flags
500.                    *range increment for data input
852.                    *max battle time
60.  500.               *output increments:  time, range
500 11111111            *nreps, initial seed
0                       *pinpoint restriction:  0=none, 1=pinfinity
95.  .05                *conf level, rel width
```

Table 9: **Output Control Flags**

FLAG	INPUT	DESCRIPTION
1	1	Normal output plus a one line summary of each replication
	2	Normal output plus a detailed account of all critical events in the battle (Do not run more than a few replications)
2	1	Output of weapon system characteristics (round type, firing times, reliability, etc.)
	2	Sample of vulnerability data for each weapon/target pairing
3	1	Output of acquisition estimates for each sensor
	2	Output of acquisition estimates for every change in atmospherics caused by artillery smoke
4	1	Trace entry and exit from important routines (Do not run for more than a few replications)
5	1	Output all events as they are scheduled and canceled (Do not run for more than a few replications)
6	1	Output of killer-victim scoreboards by range
7	1	Output of distribution of shots for each weapon type

Table 10: **User Defined Terrain Statistics Input**

Line			
1	`Number of points in In-View and Out-of-View distributions,`		
	`Number of points in Opening Range distribution`		
2	`Range1`	`Probability1 (of Opening Range at Range1)`	
3	`Range2`	`Probability2 (of Opening Range at Range2)`	
:	:	:	
n	`RangeN`	`1.0`	
n+1	`Range1`	`Probability1 (In-View)`	`Probability1 (Out-of-View)`
n+2	`Range2`	`Probability2 (In-View)`	`Probability2 (Out-of-View)`
:	:	:	:
n+m	`RangeM`	`1.0`	`1.0`

2.2 Unit Deployment File

The force size, the location, the exposure and the type of combatants for each army are defined in the unit deployment file. Within this file are specified the names of the vehicles, weapons, and sensors which will be used in the simulation. These names are important, as they will be used throughout the other data files. Each army has a unit deployment file which must be named *bunit* for BLUE and *runit* for RED. The structure of these files is shown in Table 11. Table 12 shows the input variable definitions for it.

Table 11: **Unit Deployment File**

Line									
0	**	Comment Line(s)							
1	*	unit	number	type of	exposure	location	vehicle	weapon	sensor
2	*	name		combatant			name	name	name
3		COMPANY	2	Defender	HD	4000.	BRAD	TOW2	ANTAS
4		RECON	4	Defender	HD	4500.	HMMWV	COAX	ANTAS
5+		:	:	:	:	:	:	:	:

Table 12: **Unit Deployment File Input Definitions**

VARIABLE	DEFINITION
Unit Name	Used to distinguish combatants of this unit type from those in other unit types. A unit type is defined by combatant type, exposure, initial location, vehicle type, weapon type, and sensor type. All output will be shown in reference to these unit names.
Number	The number of combatants of this unit type.
Tcombat	Type of combatant. *[Defender, Attacker, or Overwatch]*
Exposure	The exposure of the units is either hull defilade (HD) or fully exposed (FE). Both defending and overwatch units are stationary, and can be either HD or FE. Defenders will begin firing upon detection whereas units in overwatch can deploy the tactic that they will not engage until an enemy vehicle has begun the battle (overwatch tactic is set in the army file). Attackers are moving, and should be fully exposed. For a stationary engagement both forces are stationary; one force will consist of all defenders, and the other will be all overwatch. For an attack scenario, the attacking force will consist of attacker units and overwatch units against defending units.
Location	This is the location of these units on the battlefield in meters. Because of the way the model keeps track of the units, attackers move in the positive direction. For example, if the battle is a BLUE attack and the initial battle range is 4000 meters, the RED defense would be placed at 4000. and the BLUE attackers would be started at 0 meters. Overwatch units can be placed at any range.
Vehicle Name	A seven-character or less vehicle type identification. These names will be used in the other input files and the names must match. The different vehicles, weapons, and sensors can be mixed between the different units.
Weapon Name	A seven-character or less weapon type identification. These names will be used in the other input files and the names must match. The different vehicles, weapons, and sensors can be mixed between the different units.
Sensor Name	A seven-character or less sensor type identification. These names will be used in the other input files and the names must match. The different vehicles, weapons, and sensors can be mixed between the different units.

2.3 Vehicle File

The vehicle files contain data which describe system platforms. The file describes such characteristics as the physical size and the speed of the vehicles. For each army there is one vehicle file which contains a subsection for each vehicle in that army. The BLUE vehicle file is called *bveh*, and the RED file is called *rveh*. Each subsection has the same structure, and the subsections can be entered in the file in any order. The vehicle names used in this file must agree with those specified in the unit deployment file.

Table 13 shows the structure of the vehicle subsection. Each subsection can begin with description or comment lines to denote what this vehicle is (e.g., **** M1A1 **** or **** M1A1 with 20 percent signature reduction*). The lines in the sample which begin with "–" must remain in the file or an error will result. They are included to help the user when entering the data. Tables 14 through 19 list the vehicle file input variable definitions.

Table 13: Vehicle File

Line	
0	** Comment Line(s)
1	Vehicle Name
2	--Turret dimensions: Height 1/2 Width Length: Front Back
3	x.x x.x x.x x.x
4	--Hull dimensions: Height 1/2 Width Length: Front Back
5	x.x x.x x.x x.x
6	--Tgt Acq data: Hull Defilade Fully Exposed
7	x.x x.x *Optical Contrast
8	x.x x.x *Thermal Contrast
9	x.x x.x *Characteristic Dimension
10	x.x x.x *Radar Cross Section
11	--Movement: max speed acceleration deceleration Pause-in-Def
12	x.x x.x x.x x
13	--Times to Leave the Battle: Jockey When Empty When F-Killed
14	xx.x xx.x xxx.x
15	--Active Protection: Arc of Protection Number of Launches
16	xx.x xx
17	--Num Ranges
18	x
19	Weapon Name
20	--Hull Defilade
21	-- P(Det) P(fire)/hit P(fire)/miss P(intercept)
22	x.xx x.xx x.xx x.xx
23	-- Range Degradation Factors: 0 30 60 90 120 150 180
24	range1 x.xx x.xx x.xx x.xx x.xx x.xx x.xx
:	: : : : : : : :
32	rangeN x.xx x.xx x.xx x.xx x.xx x.xx x.xx
33	--Fully Exposed
34	-- P(Det) P(fire)/hit P(fire)/miss P(intercept)
35	x.xx x.xx x.xx x.xx
36	-- Range Degradation Factors: 0 30 60 90 120 150 180
37	range1 x.xx x.xx x.xx x.xx x.xx x.xx x.xx
:	: : : : : : : :
45	rangeN x.xx x.xx x.xx x.xx x.xx x.xx x.xx
46	END
47	--Smoke Grenades: Ngren P(Launch) alpha-CLs Time to Deploy Duration
48	xx x.x x.x x.x x.x xx.x xx.x
49	--Laser Warning Recvr: On/Off P(det) Pop-smoke Engage Hide nFOV Tsearch
50	T/F x.x T/F T/F T/F x.x x.x

Table 14: **Vehicle File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Vehicle Name	Seven character vehicle name must agree with use in other files.
3	*Turret Dimensions:*	
	Height	Height in meters of box which represents turret
	1/2 Width	1/2 width in meters of box which represents turret
	Front Length	Length in meters of front part of box which represents turret
	Back Length	Length in meters of back part of box which represents turret
5	*Hull Dimensions:*	
	Height	Height in meters of box which represents hull
	1/2 Width	1/2 width in meters of box which represents hull
	Front Length	Length in meters of front part of box which represents hull
	Back Length	Length in meters of back part of box which represents hull
Target Acquisition:		
7	Optical Contrast (HD)	Optical contrast for this vehicle when in a hull defilade position. Used when a visual sensor is looking at it. It is defined as the the difference between the average luminance of the vehicle and the average luminance of the background divided by the average luminance of the background.
	Optical Contrast (FE)	Optical contrast for this vehicle when in a fully exposed position.

Table 15: **Vehicle File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
8	Thermal Contrast (HD)	Thermal contrast for this vehicle when in a hull defilade position. Used when a thermal sensor is looking at it. It is defined as the the difference between the average temperature of the vehicle and the average temperature of the background in degrees Celsius.
	Thermal Contrast (FE)	Thermal contrast for this vehicle when in a fully exposed position.
9	Charac Dim	Characteristic Dimension. Used for both visual and thermal sensors. It is the square root of the product of the vehicle's height times the vehicle's width (in meters). Entered for hull defilade, and for fully exposed. These do not neccessarily need to be the same as the vehicle's box dimensions as input on lines 3 and 5.
10	Radar Cross Section	Used when the opposing sensor is a radar acquisition device. This is most commonly referred to simply as the cross section or target size in meters squared. More precisely, it is the area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target.
12	Max speed	Maximum speed in meters/second that the vehicle may move. For attacking vehicles, this is the speed at which the units move closer to the defender locations. Even if the vehicle is to be stationary in the battle, the user must input a non-zero maximum possible speed. Note: This is really a *Radial Approach* velocity.
	Acceleration	Acceleration of the vehicle in m/s2
	Deceleration	Deceleration of the vehicle in m/s2
	Pause in Defilade	This variable controls the movement of attackers when engaging a target, and line-of-sight (LOS) is about to break. An input value of "1" causes the attacker to move to a hull defilade posture and halt, keeping LOS to the target in order to continue the engagement. An input value of "0" allows the attacker to continue advancing, thus discontinuing the engagement when LOS breaks.

Table 16: **Vehicle File Input Definitions - Continued (2)**

LINE	VARIABLE	DEFINITION
14		*Time to Leave Battle:*
		During the battle certain situations prompt a vehicle to attempt to leave the battlefield. The inputs on this line are the mean time in seconds to leave the battlefield and reach a full defilade posture. The model draws from a normal distribution about this mean when calculating the appropriate time.
	Jockey	Time (secs) to leave battle for a defender or an overwatch vehicle, when it pops down to either move to a new position or to reload a missile pod.
	When Empty	Time (secs) to leave battle when a unit (vehicle) is out of ammunition and tries to move to a full defilade position to avoid being killed.
	When F-killed	Time (secs) to leave battle after a unit (vehicle) is F-killed and can no longer fire.
		APS:
		An *active protection system (APS)* is a vehicle survivability enhancement, which may detect and change the effectiveness of an incoming projectile. The APS protects an area defined by an arc centered at the front of the vehicle and may be deployed a set number of times. The system works in four stages: detection, fire, intercept, and degrade.
16	Arc of Protection	The arc (degrees) in front of the vehicle the APS will cover.
	Num Launches	The number of times the vehicle can activate its APS.
		If, and only if, the number of times the system may activate is greater than zero the user needs to enter the additional information which defines the APS:
18	Num Ranges	Number of range entries for degradation factors (see below). The range entries must be in increments as specified in the game file. The first value must be equal to the range increment, and the last range value must be greater than or equal to the max firing range of the enemy weapon system.

Table 17: **Vehicle File Input Definitions - Continued (3)**

LINE	VARIABLE	DEFINITION
19	Weapon	Seven-character weapon name, against which the APS will activate.
22	Pdet(HD)	Probability of detecting the incoming round (when in hull defilade)
	Pfh(HD)	Probability of firing at an incoming round that will hit (when in hull defilade)
	Pfm(HD)	Probability of firing at an incoming round that will miss (when in hull defilade)
	Pint(HD)	Probability of intercepting the incoming round (when in hull defilade)
24-32	Range	Range increment (m) for which the degradation factors apply
	Degradation Factors	The degradation factors for each 30 degree sector within the arc of protection. These factors are multiplied times the lethality of the incoming round (i.e., if P(kill)=.6 and deg. factor=.2, the resultant P(kill)=.12).
35	Pdet(FE)	Probability of detecting the incoming round (when fully exposed)
	Pfh(FE)	Probability of firing at an incoming round that will hit (when fully exposed)
	Pfm(FE)	Probability of firing at an incoming round that will miss (when fully exposed)
	Pint(FE)	Probability of intercepting the incoming round (when fully exposed)

Table 18: **Vehicle File Input Definitions - Continued (4)**

LINE	VARIABLE	DEFINITION
37-45	Range	Range increment (m) for which the degradation factors apply
	Degradation Factors	The degradation factors for each 30 degree sector within the arc of protection. These factors are multiplied times the lethality of the incoming round (i.e., if P(kill)=.6 and deg. factor=.2, the resultant P(kill)=.12).
Additional sets of input consisting of (weapon name, probabilities, and degradation) are entered next for each weapon against which this system is effective. When all affected weapons have been entered, enter "END" as the next line.		
46	END	End of APS section.
		Smoke Grenades:
		Another survivability enhancement modeled is an on board *smoke grenade system.* The system has the ability to detect an incoming round and to deploy a smoke cloud around the target vehicle which affects target acquisition by and of this vehicle.
48	Num Grenades	Number of times the grenade launcher can fire. (This is not neccessarily the total number of grenades.)
	P(Launch)	Probability that the system will detect and deploy.
	Alpha-CL(opt)	Level of smoke which affects optical sensors.
	Alpha-CL(ther)	Level of smoke which affects thermal sensors.
	Alpha-CL(radar)	Level of smoke which affects radar sensors.
	Time to Deploy	The time (sec) from launch of the grenade to the effective formation of the smoke cloud around the vehicle.
	Duration	The effective duration (sec) of the smoke cloud from the time it forms.

Table 19: **Vehicle File Input Definitions - Continued (5)**

LINE	VARIABLE	DEFINITION
		LWR:
		The last survivability enhancement is a *laser warning receiver (LWR)* system which may be activated when the vehicle gets lased prior to being engaged. For the LWR to react, the engaging weapon system must be using a laser range finder (defined in the weapon input file). Three reactions by the lased vehicle are possible: 1) Pop smoke grenades, 2) Turn and engage the combatant who lased, and 3) Attempt to reach a full defilade posture. Any combination of these reactions can be played simultaneously.
50	If LWR	If there is an LWR on board, true or false (T/F).
	P(det)	Probability that the LWR will detect that it has been lased, and react.
	Pop-Smoke	T/F. If T, user must enter appropriate values on the smoke grenade line (48 above). If smoke grenades are to be triggered by LWR only, the probability of sensing, *P(Launch)*, on line 48 above must be set to 0.0.
	Engage	T/F. T if tactic is to turn to engage combatant who lased. (If T, see last two input variables on this line.)
	Hide	T/F. T if tactic is to attempt to reach a full defilade position.
	Num FOV	When the *Engage* tactic is played, the LWR can achieve different levels of accuracy when pointing in the direction of the threat. If the LWR can give a precise location of the enemy, the entry for this input is 1.0. The lased vehicle's observer then searches in NFOV and the only requirement is to check if .75 line pairs can be resolved across the target (detection criteria). Otherwise the user should enter the general area to search for the threat as a number of fields of view of the appropriate sensor. In this case, the lased vehicle's observer searches in WFOV for these number of fields of view for the enemy using detection criteria (.75 line pairs). Once acquired in WFOV, the observer must then attempt to acquire the enemy in NFOV, as usual.
	Tsearch	When the *Engage* tactic is played, the time (sec) to search for the enemy before resuming normal search.

2.4 Weapon File

There is a BLUE weapons file, *bweap*, and a RED weapons file, *rweap*. Each file contains subsections which describe one weapon system each. For each weapon subsection the user defines firing times, reliability, times to reload, type of round etc. The general structure of the *Weapon File* is shown in Table 20. Tables 21 through 28 list the Weapon File input variable definitions.

Table 20: **Weapon File**

Line	
0	`** Comment Line(s)`
1	`Weapon Name`
2	`--Type FireMax Nrounds Halt-to-fire Tactic Nrpt LRF isLO`
3	`xx xxxx. xx x x xx T/F T/F`
4	`--Inputs by Range: P(sense), T(flight), T(first), T(fixed), Reliab`
5	`x.xx x.xx x.xx x.xx ... x.xx x.xx ** P(sense)`
6	`xx.x xx.x xx.x xx.x ... xx.x xx.x ** T(flight)`
7	`xx.x xx.x xx.x xx.x ... xx.x xx.x ** T(first)`
8	`xx.x xx.x xx.x xx.x ... xx.x xx.x ** T(fixed)`
9	`x.xx x.xx x.xx x.xx ... x.xx x.xx ** Reliability`
10	`--Jockeying: If-Pop N(jockey) T(jockey)`
11	`x xx xx.x`
12	`--Subsequent Firing: T(median) T(min)`
13	`x.x x.x`
14	`--Burst Fire: Rate-of-Fire Nrnds/burst`
15	`x.x x`
16	`--Missiles: Disengage NinPod Ntgts T(reload) P(abt)/smk P(abt)/terr`
17	`x x x xx.x x.xx x.xx`
18	`--Multiple Engagement: If-Mult T(mult) N(mult) Reload-part`
19	`x xx.x x x`
20	`--Lock-on Data: Max lock-on tries`
21	`x`
22	`--Battery Coolant Unit cooldown time`
23	`xx.x`
24	`--Prob(Lock-on) by Range: stat/HD, stat/FE, moving/FE`
25	`x.x x.x x.x ... x.x x.x ** stat/HD`
26	`x.x x.x x.x ... x.x x.x ** stat/FE`
27	`x.x x.x x.x ... x.x x.x ** moving/FE`
28	`--Mean(Lock-on) by Range: stat/HD, stat/FE, moving/FE`
29	`xx.x xx.x xx.x ...xx.x xx.x ** stat/HD`
30	`xx.x xx.x xx.x ...xx.x xx.x ** stat/FE`
31	`xx.x xx.x xx.x ...xx.x xx.x ** moving/FE`
32	`--Max(Lock-on) by Range: stat/HD, stat/FE, moving/FE`
33	`xx.x xx.x xx.x ...xx.x xx.x ** stat/HD`
34	`xx.x xx.x xx.x ...xx.x xx.x ** stat/FE`
35	`xx.x xx.x xx.x ...xx.x xx.x ** moving/FE`
36	`--Range-In`
37	`T/F`

ZZZ

Table 21: **Weapon File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Weapon Name	Seven character weapon name must agree with one of the weapon system names in the unit deployment file.
3	Type	Integer value from 1 to 4 defining the type of round: 1 = Kinetic Energy Round (KE) 2 = High Explosive Anti-Tank (HEAT) 3 = Fire and Forget Missile (FAF) 4 = Command Line-of-Sight Missile (CLOS)
	FireMax	Maximum effective firing range of the weapon
	Nrounds	Total number of rounds on board
	Halt-to-fire	Integer value defining whether system must halt to fire. 0 = System may fire weapon on the move 1 = System must halt to fire weapon
	Tactic	Integer value from 1 to 3 defining the disengagement tactic. 1 = Disengage after Catastrophic Kill 2 = Disengage after hitting the target 3 = Disengage after firing Nrpt rounds at the target (see next input)
	Nrpt	Number of rounds to fire at a target before disengaging (only used when playing tactic 3 above)
	LRF	T (true) if this weapon system uses a laser range finder prior to firing its first round of an engagement. The play of the range finder does not change the way accuracy is played. The only effect of setting this input to True is that it will now activate laser warning receivers on target vehicles. Input F for false if the weapon uses no LRF.
	isLO	T (true) if this weapon is a lock-on before launch system, otherwise, set to F (false).

Table 22: **Weapon File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
The next five lines contain data which are input by range. These data are input in range increments as specified in the game control file. Note: The first value on each line should be for the range equal to this increment (e.g., 500 meters), and not for range equal to 0 meters. There must be enough values on each line to cover up to and including the maximum firing range set on line three.		
5	P(sense)	Probability that the firer will sense the impact location of a round that misses its target.
6	T(flight)	The time (secs) of flight of the round to the various ranges.
7	T(first)	Median time (secs) to fire the first round of an engagement. Log-normal distribution draw.
8	T(fixed)	Fixed time (secs) between rounds when using an auto-loader. Always added when calculating time to fire.
9	Reliability	Probability that the round is reliable (i.e., not a dud).
11	*Jockeying:*	
		Groundwars allows systems which are either in defense or overwatch to increase survivability by moving, for a specified duration, to a full defilade posture at certain points in the battle. The input variables on this line concern jockeying.
	If-Pop	Defines whether a missile system pops down (into full defilade) to reload. The missile system remains full defilade for the specified reload time, T(reload), mentioned later. Set to 1 if it should pop-down, 0 if not.
	N(jockey)	Number of shots fired before a KE weapon system will jockey. A value of 0 specifies that the system will not jockey.
	T(jockey)	The duration of time (sec) a KE system remains in full defilade during the jockey maneuver.

Table 23: **Weapon File Input Definitions - Continued (2)**

LINE	VARIABLE	DEFINITION
13		*Subsequent Firing Times:*
		This line characterizes the subsequent firing times for the system. They are applied to all rounds fired at a target after the first for a specific engagement of firer/target. Before a subsequent round is fired, a random draw is made from a log-normal distribution about the median time to determine the random re-aiming time. This time is added to the fixed time between rounds if an auto-loader is being used. If this total time is less than the minimum time, then the minimum time to fire a subsequent round, T(min), will be used as the subsequent firing time.
	T(median)	Median time (sec) to fire a subsequent round.
	T(min)	Minimum time (sec) to fire a subsequent round.
15	Rate of Fire	Rounds per second within burst. Use 1.0 if not playing burst fire.
	Nrnds/burst	Number of rounds in a single burst. Use 1 if not playing burst fire.

Table 24: **Weapon File Input Definitions - Continued (3)**

LINE	VARIABLE	DEFINITION
17		*Missile System Attributes:*
	Disengage	For missile systems which remain exposed during reload (if-pop equal 0), there are two choices for continuing an engagement. The system may be able to keep its fix on its target and therefore resume the engagement of that target upon finishing reloading. Some systems such as a hand-held one-soldier system cannot maintain a fix on the target and must begin the acquisition process anew after reloading. If the system cannot maintain a fix on the target while reloading and must disengage, then Disengage should be set to 1. If the system can maintain a fix while reloading, Disengage should be set to 0.
	NinPod	Number of missiles on board which are ready to fire. It is this number which will be reloaded when the ready rounds are depleted.
	Ntgts	The number of rounds which can be fired nearly simultaneously when playing Multiple Engagement. Ntgts should be set to 1 when not playing multiple engagement.
	T(reload)	The time (sec) required to reload the ready-to-fire missile pod.
	P(abt)/smk	Probability that the missile will abort due to an increase in the atmospheric attenuation (smoke).
	P(abt)/terr	Probability that the missile will abort when a break in line-of-sight occurs between firer and target during missile flight.

Table 25: **Weapon File Input Definitions - Continued (4)**

LINE	VARIABLE	DEFINITION
19	*Mutiple Engagement Missiles:*	
		This line allows the play of a missile system which can queue targets and fire at them nearly simultaneously. A system may only multiply engage if its weapon type is a fire and forget missile.
	If-Mult	If multiple engagement is desired. 1 for yes, 0 for no.
	T(mult)	The time from initial detection to search for additional targets before beginning the engagement. After t(mult) has elapsed the firer will begin the engaging whatever number of targets have been acquired.
	N(mult)	The total number of targets to try to multiply engage. After n(mult) targets have been detected, the firer will fire a single shot at each target and disengage.
	Reload-part	When playing multiple engagement, a system is able to reload part of its missile pod so that it always has a full pod when engaging targets. Reload-part should be set to 1 if the system can reload part of the pod, and if that is the desired tactic.

Table 26: **Weapon File Input Definitions - Continued (5)**

LINE	VARIABLE	DEFINITION
		Lock-on Before Launch Systems:
		Lines 21 through 35 describe input for a lock-on before launch system, (e.g., *Javelin*). This section should only be present if the lock-on parameter, $isLO$, on line 3 above is set to *True*. The methodology is as follows: After a target is acquired, a uniform random number [0,1] is drawn. If the random number is less than or equal to the probability of lock-on, a lock-on event is scheduled in t seconds. The time t is sampled from a log-normal distribution using the mean lock-on time, and is bounded by the maximum value *tmax(lock-on)*, and added with the BCU cooldown time. If the random number drawn was greater than the probability of lock-on, a *failed-lock-on attempt completion* is scheduled in t seconds (where t in this case is BCU cooldown time plus tmax(lock-on)). At lock-on attempt completion time, the following will occur. If the event was a *lock-on success* then a firing time is scheduled (based on time to fire first round and t-fixed). If the event was a *lock-on failure* then the number of lock-on tries is examined. If the number of lock-on tries to this point is less than max-lock-on-tries, then another lock-on attempt is scheduled immediately. If the number of lock-on tries to this point is equal to max-lock-on-tries, then the firer disengages the target and will enter search mode to look for new targets. If no new targets are found, the firer will return to this target to try another series of lock-on attempts in n seconds. This time n is input as $TLOOK$ and is the same time used to reschedule a narrow-field-of view acquisition attempt after a wide-field-of-view success but narrow-field-of-view failure.
21	Max lock-on tries	Maximum number of times the gunner will try to achieve lock-on to target before giving up and looking for other targets.
23	BCU Ctime	Battery Coolant Unit cooldown time in seconds. This is the time it takes for a disposable assembly such as a BCU (battery coolant unit) on a *Javelin* to mate to the round to provide both power and cooling gases to the seeker.

Table 27: **Weapon File Input Definitions - Continued (6)**

LINE	VARIABLE	DEFINITION
The next three lines contain data which are input by range. These data are input in range increments as specified in the game control file. Note: The first value on each line should be for the range equal to this increment (e.g., 500 meters), and not for range equal to 0 meters. There must be enough values on each line to cover up to and including the maximum firing range set on line three.		
25	P(Lock-on) stat/HD	Probability that the missile will lock-on to a target which is stationary and hull defilade.
26	P(Lock-on) stat/FE	Probability that the missile will lock-on to a target which is stationary and fully exposed.
27	P(Lock-on) mov/FE	Probability that the missile will lock-on to a target which is moving and fully exposed.
The next three lines also contain data which are input by range, to be input similarly to the three lines above.		
29	Mean(Lock-on) stat/HD	Mean time (sec) for the missile to lock onto a target which is stationary and hull defilade.
30	Mean(Lock-on) stat/FE	Mean time (sec) for the missile to lock onto a target which is stationary and fully exposed.

Table 28: **Weapon File Input Definitions - Continued (7)**

LINE	VARIABLE	DEFINITION
31	Mean(Lock-on) mov/FE	Mean time (sec) for the missile to lock onto a target which is moving and fully exposed.
The next three lines also contain data which are input by range.		
33	Max(Lock-on) stat/HD	Maximum time (sec) for the missile to lock onto a target which is stationary and hull defilade.
34	Max(Lock-on) stat/FE	Maximum time (sec) for the missile to lock onto a target which is stationary and fully exposed.
35	Max(Lock-on) mov/FE	Maximum time (sec) for the missile to lock onto a target which is moving and fully exposed.
The next data line (37) should only be present if the system is a burst-fire weapon (i.e., the input variable Nrnds/burst on line 15 above was set to a value greater than one).		
37	Range-In	T or F for true or false. *Ranging-in* is a process used by gunners to adjust fire on the target. The range-in process lowers accuracy errors for weapon systems with limited fire control, since the gunner must correct for errors associated with target range estimation, system biases, etc. The gunner achieves more accurate fire by adjusting the aimpoint in response to the perceived impact location of the preceding round. If this variable is set to T, then a Ranging-in file must be input (described later).

2.5 Sensor File

Groundwars allows the user to play optical, thermal, or millimeter wave devices, with a total of 6 sensors for both sides. As with the vehicle and weapon files, the sensor file is a group of subsections, one for each sensor. The BLUE sensor file is named *bsens* and the RED is *rsens*.

For optical and thermal devices, the model uses a form of the NVESD (Night Vision Electronic Sensors Directorate) target acquisition methodology to determine acquisition capability. Groundwars now models both wide and narrow field of view search, and input data is needed for both. For observers having both wide and narrow field of view on their sensor, Groundwars starts their search process with observers initially using their wide field of view (WFOV). After successful acquisition in WFOV, the observer will switch to narrow field of view (NFOV) and attempt to find the target based on the desired level of target discrimination for engaging in NFOV. If the target is not acquired in NFOV, the observer will switch back to WFOV to continue searching.

The level of target discrimination desired is specified by the user in the sensor input file for both WFOV and NFOV. The *Johnson Line Pair Criteria, N50*, are an empirically determined set of values used to define four levels of target discrimination. These values, N50, are the number of resolved cycles such that half the observers can discriminate a target at the respective level. The discrimination levels are defined as follows:

- Detection is the ability of an observer to distinguish that an object is of military interest.
- Classification is the ability to distinguish a target by general type; i.e. a tracked versus a wheeled vehicle.
- Recognition is the ability to distinguish between two targets of similar type; i.e. between two types of tracked vehicles, such as APCs and tanks.
- Identification is the ability to discriminate the exact model of a target; i.e. a T72 or M1 tank.

In order to reflect the combination of vertical and horizontal resolution in the two dimensional MRTD (Minimum Resolvable Temperature Difference), it is necessary to adjust the traditional Johnson cycle criteria. The following recommendations have been made by NVESD for N50 values when using 2D MRTD methodology:

- Detection - 0.75
- Classification - 1.50
- Recognition - 3.00
- Identification - 6.00

These cycle criteria should be used across all sensors: DVO, TV, I2, and thermal imagers (both first and second generation).

The performance of a millimeter wave sensor in the model is fixed except for changes in the atmosphere and differences in target RCS. The required data for optical and thermal devices is different from that for a radar device, so the structures of the subsection for the two types will be listed in separate tables. Table 29 lists the input structure for a VISUAL or THERMAL sensor. Table 34 lists the input structure for a RADAR sensor. Tables 30 through 33 lists the input variable definitions for the VISUAL or THERMAL sensor file and Table 35 lists the definitions for the RADAR file.

Table 29: **Sensor File - VISUAL/THERMAL**

Line	
0	`** Comment Line(s)`
1	`Sensor Name`
2	`-- Sensor Type: VISUAL or THERMAL`
3	`-- Data Type: TWENTY or NVLEXP`
	(If data type is TWENTY, enter two 20-point curves for each FOV: one curve for Minimum Resolvable Contrast (MRC) or Temperature Difference (MRTD), and another curve for Spatial Frequency)
4	`-- NFOV`
5	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
6	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
7	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
8	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
9	`-- WFOV`
10	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
11	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
12	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
13	`x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx`
	(If data type is NVLEXP, enter 7 coefficients for each FOV)
4	`-- NFOV`
5	`xx.xx xx.xx xx.xx xx.xx xx.xx xx.xx xx.xx`
6	`-- WFOV`
7	`xx.xx xx.xx xx.xx xx.xx xx.xx xx.xx xx.xx`
	(lines 8 through 13 omitted for data type NVLEXP)
14	`-- Horizontal FOS, Vertical FOS`
15	`xx.x xx.x`
16	`-- Horizontal NFOV, Vertical NFOV`
17	`xx.x xx.x`
18	`-- Horizontal WFOV, Vertical WFOV`
19	`xx.x xx.x`
20	`-- NFOV Magnification, WFOV Magnification`
21	`x.x x.x`
22	`-- NFOV Stat Acq Level, NFOV Mov Acq Level, tnfov`
23	`x.x x.x xx.x`
24	`-- WFOV Stat Acq Level, WFOV Mov Acq Level`
25	`x.x x.x`
26	`-- N(dets), pfalse(HD), pfalse(FE)`
27	`x x.xx x.xx`
28	`-- Pinpoint probabilities`
29	`weapon1 x.xx`
30	`weapon2 x.xx`
:	`: :`
n	`weaponN x.xx`
n+1	`END`

Table 30: **VISUAL/THERMAL Sensor File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Sensor Name	Character String must agree with one of the sensor names in the unit deployment file.
2	Sensor Type	Character String: VISUAL or THERMAL
3	Data Type	Character String: TWENTY or NVLEXP. Data for visual or thermal sensors can be input in one of two ways. For TWENTY, the user enters two performance curves for NFOV and two for WFOV, which contain twenty points each (MRTD or MRC, and then spatial frequency). For NVLEXP the user enters seven coefficients to fit a sixth degree polynomial.
The following lines (4 through 13) are input when Data Type (above in line 3) is TWENTY.		
4	NFOV	Narrow Field of View (Header)
5	MRC or MRTD	MRC (if VISUAL sensor) or MRTD (if THERMAL sensor) curve values 1 through 10 for NFOV
6	MRC or MRTD	MRC (if VISUAL sensor) or MRTD (if THERMAL sensor) curve values 11 through 20 for NFOV
7	SpaFreq	Spatial Frequency curve values 1 through 10 for NFOV
8	SpaFreq	Spatial Frequency curve values 11 through 20 for NFOV
9	WFOV	Wide Field of View (Header)

Table 31: **VISUAL/THERMAL Sensor File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
10	MRC or MRTD	MRC (if VISUAL sensor) or MRTD (if THERMAL sensor) curve values 1 through 10 for WFOV
11	MRC or MRTD	MRC (if VISUAL sensor) or MRTD (if THERMAL sensor) curve values 11 through 20 for WFOV
12	SpaFreq	Spatial Frequency curve values 1 through 10 for WFOV
13	SpaFreq	Spatial Frequency curve values 11 through 20 for WFOV
The following lines (4 through 7) are input when Data Type (above, line 3) is NVLEXP.		
4	NFOV	Narrow Field of View (Header)
5	NVLEXP	Seven coefficients for calculating spatial frequency for NFOV
6	WFOV	Wide Field of View (Header)
7	NVLEXP	Seven coefficients for calculating spatial frequency for WFOV
(Lines 8 - 13 omitted for data Type NVLEXP)		
Lines 15 through 19 give the fields of view (FOV) and search (FOS). The FOV are characteristic of the sensor, and the FOS are based on battlefield responsibility.		
15	Hor FOS	Horizontal Field of Search (degrees)
	Ver FOS	Vertical Field of Search (degrees)

Table 32: **VISUAL/THERMAL Sensor File Input Definitions - Continued (2)**

LINE	VARIABLE	DEFINITION
17	Hor NFOV	Horizontal Narrow Field of View (degrees)
	Ver NFOV	Vertical Narrow Field of View (degrees)
19	Hor WFOV	Horizontal Wide Field of View (degrees)
	Ver WFOV	Vertical Wide Field of View (degrees)
21	NFOV Mag	Narrow Field of View Magnification
	WFOV Mag	Wide Field of View Magnification
23	NS Acq	NFOV Stationary Acquisition Level (level of acquisition desired against stationary targets, in values of N50, the Johnson Line Pair Criteria).
	NM Acq	NFOV Moving Acquisition Level (level of acquisition desired against moving targets, in values of N50, the Johnson Line Pair Criteria).
	T(NFOV)	Time (sec) to search in NFOV before giving up and switching back to WFOV, if a target is not acquired.
25	WS Acq	WFOV Stationary Acquisition Level (level of acquisition desired against stationary targets, in values of N50, the Johnson Line Pair Criteria).
	WM Acq	WFOV Moving Acquisition Level (level of acquisition desired against moving targets, in values of N50, the Johnson Line Pair Criteria).

Table 33: **VISUAL/THERMAL Sensor File Input Definitions - Continued (3)**

LINE	VARIABLE	DEFINITION
27	N(dets)	The number of targets which may be detected concurrently *(hunter-killer)* by a system with this sensor. If this sensor must remain fixed on the target while the gunner services the target, *n(dets)* should be set to 1. If other targets can be detected while the gunner is busy, *n(dets)* should be set to greater than 1.
	pfalse(HD)	Probability that a detected target in hull defilade is a false target. When a hull defilade target is first detected, a random draw is made against this probability to see if a false target will be randomly substituted for the real target.
	pfalse(FE)	Probability that a detected target that is fully exposed is a false target. When a fully exposed target is first detected, a random draw is made against this probability to see if a false target will be randomly substituted for the real target.
The last section defines the probabilities of this sensor detecting the firing signatures of other weapons in the battle. On each line enter another weapon name and the probability of detection given the weapon fires. Weapon names must match weapon names as input in the weapon file. When all desired weapon have been input, enter "END" to end the pinpoint section.		
29-n	Weapon	Character String of firing weapon
	P(pinp)	Probability of sensor detecting weapon by its flash.
n+1	END	End of Pinpoint section.

Table 34: **Sensor File - RADAR**

Line	
0	`** Comment Line(s)`
1	`Sensor Name`
2	`-- RADAR`
3	`-- If-rain,  Clutter`
4	`x            x.x`
5	`-- N(dets),  pfalse(HD),  pfalse(FE)`
6	`x            x.xx          x.xx`
7	`-- Pinpoint probabilities`
8	`weapon1   x.xx`
9	`weapon2   x.xx`
:	`:         :`
n	`weaponN   x.xx`
n+1	`END`

Table 35: **RADAR Sensor File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Sensor Name	Character String must agree with one of the sensor names in the unit deployment file.
2	Sensor Type	Character String: RADAR
		Rain and clutter will affect radar acquisition.
4	If-rain	Input 1 for rain, else 0 for no rain.
	Clutter	Level of Clutter. Use 1.0 for Low Clutter, and greater than 1.0 for High Clutter.
5 to END		*Same as lines 26 to END in VISUAL/THERMAL Sensor File.*

2.6 Accuracy File

For each weapon system defined in the two unit deployment files, there must be a file which contains weapon system delivery accuracies. BLUE accuracy files have the form *bacc?* where *?* is an integer representing the number of the blue weapon system. For example, if there are three different blue weapon systems, the blue accuracy files must be named, *bacc1, bacc2,* and *bacc3.* The same structure holds for all RED accuracy files, racc?. Each file has the structure shown in either Tables 36 and 37 for non-burst-fire systems, or Table 38 for a burst-fire weapon.

The model requires shot biases and dispersions for three situations: stationary firer against a stationary target, a stationary firer against a moving target, and a moving firer against a stationary target. Groundwars does not model a moving firer against a moving target, and so does not require input data for this situation.

The file is free formatted, and all lines which begin with an "*" are comment lines included for clarity; comment lines may be added or removed between groups of data, but not within a group of data. All ranges are in meters, and all biases and errors are in *mils* (angular measurement equal to 1/6400 of a circle).

There exist three types of errors which are read into the model and can be classified according to how long they persist. *Fixed biases* are those which persist over many engagements. *Variable biases* are caused by transient effects such as cross wind, and vary from engagement to engagement. *Random errors* are those which change from round to round within an engagement and are caused by differences in individual rounds, wind gusts, etc.

The first two lines of each file must contain a weapon name and the number of range increments which will be input. The range input must account for all ranges from 0 up to and including the maximum firing range of the weapon.

The first section of the file is for a stationary firer against a stationary target. For this situation data is required for the first round fired and for subsequent rounds. For first rounds, fixed bias, variable bias and random error are required. For subsequent rounds only random error is needed. This error varies depending on whether the previous shot was a hit, a lost miss, or a sensed miss. Misses are either lost or sensed depending on the value of *p(sense)* in the weapon description file. For the number of ranges to be input, the user will enter a range and its corresponding errors for first and subsequent rounds.

The second section of the file is for a stationary firer against a moving target. This section has only two types of error: fixed bias and total error, which should include the variable bias, add-on, and subtractive dispersions for a moving target. These errors are required for four different attack angles: 0, 30, 60, and 90 degrees as is shown in the table.

The third section is for a moving firer against a stationary target. Only fixed bias and total error are required at each range.

The accuracy input for a burst-fire weapon is similar (see Table 38), but with a few differences. The variable bias is input for first burst and subsequent bursts separately. There is no input for random error based on the result of a previous round. And there is no breakdown by attack angle. Also, for a burst-fire weapon, if ranging-in is played (as specified in the weapon file), then a ranging-in file must be prepared for input (described later).

Table 36: **Accuracy File: Non-burst**

```
** Comment Line(s)
Weapon Name
x ranges
*                        STATIONARY FIRER vs STATIONARY TARGET
*                        -------------------------------------
*                  1st Round                       h/h       h/lm       h/sm
*           -----------------------------     --------- --------- ---------
*           fix bias  var bias   ran err       ran err   ran err   ran err
*           --------- --------- ---------     --------- --------- ---------
*  rg (m)     H    V    H    V    H    V        H    V    H    V    H    V
*  ------   ---- ---- ---- ---- ---- ----     ---- ---- ---- ---- ---- ----
    rng1    .xxx .xxx .xxx .xxx .xxx .xxx     .xxx .xxx .xxx .xxx .xxx .xxx
     :        :    :    :    :    :    :        :    :    :    :    :    :
    rngN    .xxx .xxx .xxx .xxx .xxx .xxx     .xxx .xxx .xxx .xxx .xxx .xxx
*
*
*              STATIONARY FIRER vs MOVING TARGET
*              ---------------------------------
*                              0 deg
*                    fixed bias                total error
*                    ----------              -------------
*  rg (m)      H           V             H           V
*  ------   -------     -------       -------     -------
    rng1      .xxx        .xxx          .xxx        .xxx
     :          :           :             :           :
    rngN      .xxx        .xxx          .xxx        .xxx
*
*                              30 deg
*                    fixed bias                total error
*                    ----------              -------------
*  rg (m)      H           V             H           V
*  ------   -------     -------       -------     -------
    rng1      .xxx        .xxx          .xxx        .xxx
     :          :           :             :           :
    rngN      .xxx        .xxx          .xxx        .xxx
*
*                              60 deg
*                    fixed bias                total error
*                    ----------              -------------
*  rg (m)      H           V             H           V
*  ------   -------     -------       -------     -------
    rng1      .xxx        .xxx          .xxx        .xxx
     :          :           :             :           :
    rngN      .xxx        .xxx          .xxx        .xxx
*
```

Table 37: **Accuracy File: Non-burst - Continued (1)**

```
*
*                               90 deg
*                  fixed bias                  total error
*                  ----------                  -------------
*  rg (m)        H           V              H            V
*  ------     -------     -------        -------      -------
    rng1       .xxx        .xxx           .xxx         .xxx
     :          :           :              :            :
    rngN       .xxx        .xxx           .xxx         .xxx
*
*             MOVING FIRER vs STATIONARY TARGET
*             ---------------------------------
*                      fixed bias               total error
*                      -------------            -------------
*  rg (m)           H        V              H        V
*  ------         ----     ----           ----     ----
    rng1       .xxx        .xxx           .xxx         .xxx
     :          :           :              :            :
    rngN       .xxx        .xxx           .xxx         .xxx
```

Table 38: **Accuracy File (Burst-Fire)**

```
** Comment Line(s)
Weapon Name
*                           STATIONARY-STATIONARY
*
x ranges                       Variable Bias
*            fix bias     1st bst    sub bsts        ran err
*            ---------   ---------   ---------     -----------
*  rg (m)      H    V      H    V      H    V        H    V
*  ------    ---- ----   ---- ----   ---- ----     ---- ----
    rng1     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
     :         :    :      :    :      :    :        :    :
    rngN     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
*
*                            STATIONARY-MOVING
*
*                              Variable Bias
*            fix bias     1st bst    sub bsts        ran err
*            ---------   ---------   ---------     -----------
*  rg (m)      H    V      H    V      H    V        H    V
*  ------    ---- ----   ---- ----   ---- ----     ---- ----
    rng1     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
     :         :    :      :    :      :    :        :    :
    rngN     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
*
*                            MOVING-STATIONARY
*
*                              Variable Bias
*            fix bias     1st bst    sub bsts        ran err
*            ---------   ---------   ---------     -----------
*  rg (m)      H    V      H    V      H    V        H    V
*  ------    ---- ----   ---- ----   ---- ----     ---- ----
    rng1     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
     :         :    :      :    :      :    :        :    :
    rngN     .xxx .xxx   .xxx .xxx   .xxx .xxx     .xxx .xxx
```

2.7 Vulnerability Files

Traditional vulnerability calculations make use of a mapping procedure called *damage assessment lists (DALs)* or *standard damage assessment lists (SDALs)*. A DAL maps killed components and sets of components into *Degradation of Combat Utility (DCU)* or *Loss of Function (LoF)*, typically for *Mobility (M)*, *Fire-Power (F)*, *M or F*, and *Catastrophic Kill (K)*. The DCU estimates developed in the DAL process, defined as expected loss of function values, are typically used as if they reflected probabilities of no capability. [2] The DAL vulnerability data required for input to Groundwars will be referred to as "probability of kill" in the remainder of this report.

The vulnerability files contain probability of kill information which can be entered as either the *Probability of Kill given a Hit (PKH)* or as the *Probability of Kill given a Shot (PKS)*. Probabilities of kill are generated by the Survivability/Lethality Analysis Directorate's (SLAD) Ballistic Vulnerability/Lethality Division (BVLD) of the Army Research Laboratory (ARL), formerly the Ballistic Research Laboratory (BRL). The names of these files in the current working directory are similar to those for the accuracy files. BLUE files have the prefix *bpk*, and RED files begin with *rpk*. The BLUE files will be named: *bpk1, bpk2, ..., bpk10, bpk11, ...* PK files must exist for every combination of weapon system and target vehicle that may engage one another. The model checks to see if all combinations of weapons vs. vehicles have been entered (including BLUE vs. BLUE and RED vs. RED if these combinations are specified in the *engagement* file). For those that do not exist, the model will give a warning message. The user should check these warnings for the first runs of the study to be sure that no desired combination has been missed.

The model recognizes four levels of kill: *mobility kill, fire-power kill, mobility and fire-power kill*, and *catastrophic kill*. The four levels of kill have the following results in the model: A mobility kill renders an attacker unable to continue moving; the combatant remains at its current exposure and range, and can still engage. For a defender or overwatch unit, a mobility kill means that it may no longer pop down to reload or jockey to an alternate position. A fire-power kill leaves the combatant unable to fire, and it will attempt to reach cover to avoid being killed further. For a mobility and fire-power kill, the combatant can no longer function, but it is not totally destroyed. Vehicles which have sustained one of these levels of damage continue to draw fire, and may be killed at a higher level. A catastrophically killed combatant no longer functions, and all units know that it no longer is a threat.

The first section of every file contains the same information, whether the user uses PKH or PKS. On the first line the weapon name and the target vehicle name are given; these must agree with those input in the unit deployment files. On the second line two flags are set which dictate the form of the vulnerability data. *PK-Flag1* determines if the data is entered as PKH or PKS data. If this flag is set to a 0 or a 2 the data is PKS data. If the flag is set to 1, the data is PKH. The forms of these data will be described shortly.

The second flag on the line, *PK-Flag2*, determines if the data is independent of range to the target. For some weapons the lethality of the weapon is the same at all ranges. A "0" designates lethality which is a function of range and a "1" designates range independent vulnerability.

The first two forms of data are probability of kill given a shot. The data for both forms are

[2] Work began in 1988 by ARL and AMSAA to develop improved vulnerability metrics, called *Degraded States*, which overcomes most of the mathematical problems in the DAL process [J. Abell, L. Roach, M. Starks, "DEGRADED STATES VULNERABILITY ANALYSIS," BRL Technical Report BRL-TR-3010, June 1989]. An extension of Groundwars, called *DSWARS*, was written to use these new metrics and has been used for research purposes at AMSAA [G.R.Comstock, "The Degraded States Weapons Analysis Research Simulation (DSWARS): An Investigation of the Degraded States Vulnerability Methodology in a Combat Simulation," AMSAA Technical Report 495, February 1991].

independent of target aspect angle and round dispersion. The two forms require the same data, but are entered in a different order. For both forms, the data should begin with range of 0 meters. If the first vulnerability flag is set to a 0, the data needs to be in the form shown in Table 39. When the flag is set to a 2, the data needs to be in the form shown in Table 40. When PKS data is being used, the probability of hit is forced to be 1.0 within the model, since the probability of hit was factored into the calculation of the PKS.

Table 39: **PKS Vulnerability File (PK-Flag1 = 0)**

```
** Comment Line(s)
Weapon-Name      Target-Vehicle-Name
 0    x      <-- PK-Flags
** 0m    rng2  rng3  rng4  ...  rngN  | Kill Type  | Exposure
************************************************************
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | M-Kill     |   HD
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | F-Kill     |   HD
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | MorF-Kill  |   HD
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | K-Kill     |   HD
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | M-Kill     |   FE
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | F-Kill     |   FE
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | MorF-Kill  |   FE
   x.xx  x.xx  x.xx  x.xx  ...  x.xx  | K-Kill     |   FE
```

Table 40: **PKS Vulnerability File (PK-Flag1 = 2)**

```
** Comment Line(s)
Weapon-Name      Target-Vehicle-Name
 2    x      <-- PK-Flags
**  M     F    MorF   K   |  Range   | Exposure
***********************************************
   x.xx  x.xx  x.xx  x.xx | 0 meters |    HD
   x.xx  x.xx  x.xx  x.xx | range 2  |    HD
   x.xx  x.xx  x.xx  x.xx | range 3  |    HD
   x.xx  x.xx  x.xx  x.xx | range 4  |    HD
    :     :     :     :   |   :      |    :
   x.xx  x.xx  x.xx  x.xx | range N  |    HD
                          |          |
   x.xx  x.xx  x.xx  x.xx | 0 meters |    FE
   x.xx  x.xx  x.xx  x.xx | range 2  |    FE
   x.xx  x.xx  x.xx  x.xx | range 3  |    FE
   x.xx  x.xx  x.xx  x.xx | range 4  |    FE
    :     :     :     :   |   :      |    :
   x.xx  x.xx  x.xx  x.xx | range N  |    FE
```

The third data format is the *Individual Unit Action (IUA)* file as produced by the ARL. For this type of input data, PK-flag1 should be set to 1. The data is a function of target, aspect angle, target exposure, round dispersion and kill criteria. Table 41 below shows the general structure of

this file. This file is formatted, and should be received from the ARL in this format. In certain cases, the IUA file from ARL may contain a fifth kill-type, *crew*. These are not used by Groundwars and should be deleted from the file.

For each range there is a group of 88 lines of PKH data. For vulnerability which is independent of range, there will be only one set of 88 lines. In each group of 88 lines there are 44 lines against a hull defilade target followed by 44 lines for fully exposed targets. In each group of 44 lines there are 11 sets of 4 lines. The first 10 sets of lines correspond to 10 linear dispersions (1-10 feet) and the 11th set is for a uniform distribution of shots on the target. Each of the four lines corresponds to one of the four kill categories.

Table 41: **IUA (PKH) Vulnerability File (PK-Flag1 = 1)**

```
** Comment Line(s)
Weapon-Name     Target-Vehicle-Name
 1   x     <-- PK-Flags
***  range E  D K    0     30    60    90    120   150   180   Avg
*******************************************************************
      rng1 1  1 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  3 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
       :   :  : :    :     :     :     :     :     :     :     :
      rngN 2 10 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 10 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
```

```
Definitions:
rng1 - 0 meters
rngN - last range for data
E - Target Exposure (1 for HD, 2 for FE)
D - Dispersion of round (1 to 10 feet, 11 is random dispersion)
K - Kill Type (1 is M-Kill, 2 is F-Kill, 3 is MorF-Kill, 4 is K-Kill)
Target Aspect Angle - Angle of the incoming projectile flight path
                      measured from the front of the target in the
                      horizontal plane (0 through 180 degrees).
```

2.8 Army File

The *army* file contains information that isn't specific to any one unit type. An army file is required for each army in the battle. The names of the two files are *barmy* and *rarmy*. The general structure of the file is shown in Table 42. The army file input variable definitions are listed in Tables 43 through 45.

Table 42: **Army File**

```
** Comment Line(s)
--Tactics:  Priority  T(relook)  N(bump)  T(bump)  Overw-eng
               x         xx.x       x       xx.x       x
--Communications:  If-comm  P(pass)  T(pass)  T(search)
                     x       x.xx     xx.x      xx.x
--Decoys:  DecName  N(flash)  T(start)  T(flash)
         UNIT NAME     x        xx.x      xx.x
--If Artillery
     x
    Target1
    --Prep. Artillery      M     F    M&F    K
                         x.xx  x.xx  x.xx  x.xx
    --On-call Artillery    M     F    M&F    K
                         x.xx  x.xx  x.xx  x.xx
    Target2
    --Prep. Artillery      M     F    M&F    K
                         x.xx  x.xx  x.xx  x.xx
    --On-call Artillery    M     F    M&F    K
                         x.xx  x.xx  x.xx  x.xx
    END
```

Table 43: **Army File Input Definitions**

LINE	VARIABLE	DEFINITION
2	Priority	Target priority. If a unit is able to detect more than one target concurrently, the firer will pick older targets over new if this is set to 1, and newer targets over old if this is set to 2. If the unit cannot detect more than one target, this input will have no effect.
	T(relook)	The time a firer will search for other targets before going back to a previously serviced target and renewing the engagement (only if the target is still in line of sight and is not k-killed).
	The next two input variables are used when a target vehicle is mobility&firepower killed, and is no longer functioning. A firer will recognize a target in this condition as non-threatening, and will disengage it. The firer will disengage the target after firing N(bump) rounds at it or after waiting T(bump) seconds. When either of these conditions is met, the target is "bumped up" to an unthreatening vehicle, and all units will disengage it.	
	N(bump)	The number of rounds fired before an MF-killed target is bumped up to a non-threat, allowing disengagement.
	T(bump)	Duration of time (sec) before an MF-killed target is bumped up to a non-threat, allowing disengagement.
	Overw-eng	Governs the play of overwatch vehicles for this army in the simulation. As described in the unit deployment file section, overwatch vehicles can either fire as soon as they acquire a target, or they may stay quiet until the enemy begins to fire. If the overwatch should fire upon acquiring a target, this input is a 1, else it is a 0.
The next line of input controls the play of communications between friendly vehicles.		

Table 44: **Army File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
4	If-comm	When a unit detects an enemy unit, it may pass the enemy's location to other units on its side (e.g. *IVIS - Intervehicular Information System*). If the location is received, the receiver will conduct a field of view search in the area and attempt to acquire the target. Enter a 1 as the value for *If-comm* to enable the play of this communication tactic, else enter 0.
	P(pass)	The probability that the others will receive the transmission of the target's location.
	T(pass)	The time (sec) to wait before the receiving vehicle will conduct its search.
	T(search)	Duration of time (sec) the receiving vehicle will search in the field of view before renewing normal search. To have friendly units gang up on the detected target, set this wait time to 0.0.
Decoys: The information necessary for the play of decoys is on the next line. Decoys are entered as any other unit and vehicle type in the unit deployment file. However, the weapon and sensor names should be set to "NULL" When the army file is read, the name of the decoy which is entered here is used to make all units of this type decoys. When only non-flashing decoys are played, the remaining inputs on this line should be set to 0. When flashing decoys are played the user must enter the probability of detecting the flashes in the opposing sensor file.		
6	DecName	Unit Name of decoy as entered in the Unit Deployment File.
	N(flash)	Number of flashing decoys (subset of total number of decoys).
	T(start)	Time in the battle (sec) when decoys should begin to flash.
	T(flash)	Average time (sec) between decoy flashes.

Table 45: **Army File Input Definitions - Continued (2)**

LINE	VARIABLE	DEFINITION
8	If Artillery	Set to 1 if artillery is to be played, else 0. Artillery can be preparatory or on-call. Prep artillery is called prior to the start of battle. On-call artillery is delivered during the battle at a random time. If a 0 is entered here, there will be no artillery and there are no more entries in the file. If the value entered is 1, the following lines must be input:
9	Target1	Vehicle name of target
11	PrepPKs	Probability of Kill values for prep artillery vs target1 for Mobility-only, Fire-power only, M&F-kill-only, and K-kill.
13	OnCallPKs	Probability of Kill values for on-call artillery vs target1 for Mobility-only, Fire-power only, M&F-kill-only, and K-kill.
(Lines 9 through 13 repeated for as many targets as artillery affects. If artillery is played, for each enemy vehicle which is in the intended target area, there must be entered probabilities of kill. The names of all affected units must be entered.)		
19	END	Signifies no more artillery PKs to be entered.

2.9 Obscuration File

This file defines changes in the atmospheric conditions during the battle. These changes affect all combatants across the battlefield. Smoke in the model starts at a certain time, and has a finite duration. Both of these parameters are set by the user. Any number of smoke events can be played in the model, but the more smoke events played the slower the run time will be since all probabilities of acquisition and engagements are reassessed when the atmosphere changes. This file has the name *smkfile*. If no smoke is desired in the battle, then this file does not need to exist. Table 46 shows the format of the Obscuration File and Table 48 lists the input variable definitions.

Table 46: **Obscuration File**

Line	
0	`** Comment Line(s)`
1	`** start  duration  optic  therm  radar`
2	`   xxxx.    xxx.    x.xx   x.xx   x.xx     * 1st smoke event`
3	`   xxxx.    xxx.    x.xx   x.xx   x.xx     * 2nd smoke event`
:	`    :        :       :      :      :            :`
n	`   xxxx.    xxx.    x.xx   x.xx   x.xx     * nth smoke event`

Table 47: **Obscuration File Input Definitions**

LINE	VARIABLE	DEFINITION
2	Start	Battle time (sec) when 1st smoke event starts.
	Duration	Duration (sec) of this smoke event
	Optic	Attenuation of transmission for optical sensors.
	Therm	Attenuation of transmission for thermal sensors.
	Radar	Attenuation of transmission for radar sensors.
3-n	*continues for each smoke event*	

2.10 Engagement Control File

Because Groundwars can model *fratricide*, or *'friendly fire'*, a file is needed to describe which units can engage one another. This file also eliminates the need for the simulation to calculate all of the engagement interactions that would take place between two units which would never realistically engage one another.

There is only one file, *engfile*, which describes the actions of both RED and BLUE units. If fratricide is not desired, this file can be ignored, and the model will revert to a battle with units engaging only enemy units; no friendly losses will occur. This file is somewhat complex and the user should take care in creating or modifying it.

Engagement is governed in the model by three parameters. The first parameter is a yes or no switch which determines if the engaging unit might engage units of each of the other types. Given that an observer, A_0, acquires a target, a check is then made to determine if A_0 is able to identify the target through his sensor as either friendly or enemy. The input in the sensor files governs the ability of A_0 to identify the target. 0.6 line pairs are used as the identification level criterion. If A_0 is using radar, it is assumed he cannot identify the target through his sensor. If A_0 is able to identify the target as friendly, he will break off the engagement. If A_0 identifies it as an enemy, he will engage the target as normal. If A_0 is not able to identify the target one way or the other, A_0 must make some decision whether he should engage this "grey" target. This decision is characterized in the model by the last two parameters, the *probability of engagement*, and a *time delay* associated with the decision.

The engagement file contains a subsection for each unit type in the battle. The general structure of a single subsection is shown in Table 48. The engagement file input variable definitions are listed in Table 49.

Table 48: **Engagement Control File**

Line				
0	`** Comment Line(s)`			
1	`Engaging Unit's name`			
2	`-- Target Names,`	`Is-It-A-Tgt,`	`P(engage),`	`T(engage)`
3	`TgtName1`	`x`	`x.xx`	`xx.x`
4	`TgtName2`	`x`	`x.xx`	`xx.x`
:	:	:	:	:
n	`TgtNameN`	`x`	`x.xx`	`xx.x`
n+1	`'END'`			

A sample engagement file is shown in Table 50. The first subsection is for unit type BLUE1. BLUE1 will engage both BLUE2 and RED1. However, when he cannot identify a target which he has detected, he will engage BLUE2 only 40 percent of the time, but he will engage RED1 100 percent of the time. For example, this could be because RED1 may be further away or in an area where BLUE1 knows there are no friendly units, and BLUE2 may be in an area where there is a good chance that friendly vehicles may be located. BLUE2 has the location of BLUE1 and will only engage RED1. RED1 will engage both BLUE units, and he will always engage on detection since his probabilities of engaging are 1.0.

Table 49: **Engagement File Input Definitions**

LINE	VARIABLE	DEFINITION
1	EngName1	The engaging unit's name
Following this line, there is a single line entry for all units which the engaging unit may consider as a target.		
3+	TgtName1	The engaged unit's name
	Is-It-A-Tgt	1 if TgtName1 is considered a potential tgt for EngName1, 0 if TgtName1 will not be engaged by EngName1
	P(engage)	Probability of EngName1 engaging TgtName1 when EngName1 is unable to identify TgtName1
	T(engage)	Time (sec) for EngName1 to decide to engage TgtName1 when unable to identify
Instead of listing all of the units in the battle, and entering a 0 for the ones not to be engaged, the user may enter only those wanted, and end the subsection by entering END as a unit name.		

Table 50: **Sample Engagement Control File**

```
******** Engagement Table *********
'BLUE1'                   .
-- Target Names,   Is-It-A-Tgt,   P(engage),  T(engage)
   'BLUE2'              1            0.4          5.0
   'RED1'               1            1.0          0.0
   'END'
****
'BLUE2'
-- Target Names,   Is-It-A-Tgt,   P(engage),  T(engage)
   'RED1'               1            1.0          5.0
   'END'
****
'RED1'
-- Target Names,   Is-It-A-Tgt,   P(engage),  T(engage)
   'BLUE1'              1            1.0          0.0
   'BLUE2'              1            1.0          0.0
   'END'
```

2.11 Combat Identification File 1 - Constant Emitter

Combat Identification Devices (CID) provide a means for an observer to identify a target as friend or foe in order to help prevent fratricide. Only if the engagement file exists can CID be played in Groundwars. Two ways of modeling a CID are possible in the model. The first type of combat identification device is one which constantly emits a signal *(CID1)*. These signals (emitted by *host* units) may be detected by friendly units, and sometimes enemy units. When a host unit with this type of CID is detected by a friendly observer, there is a probability associated with the CID that the observer will then know that the CID host is friendly. If this probability is met, the observer will disengage the target (host). The CID signal being emitted can also aid others in detecting the host units. This aspect of the CID is modelled as a probability of detection in a given time period. If the time period were 30 seconds, for example, a random draw is done every 30 seconds to determine if any of the searching units will detect the host because of its signal.

The information to characterize these events is entered in the input file *cidfil1*. If this file is not included in the current working directory when Groundwars is run, then CID1 will not be played. The file contains a subsection for each different unit type in the battle which has a CID1 on board. Table 51 shows a single subsection. Table 52 lists CID File 1 input variable definitions.

Table 51: **Combat Identification File 1 - Structure**

Line	
0	`** Comment Line(s)`
1	`--CID Host Name,  Time for Detection Check`
2	`'BLUE1'                xx.`
3	`-- Probability of these observers CIDing host vehicle`
4	`'BLUE2'  x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...`
5	`'END'`
6	`-- Probability of these observers detecting host vehicle's CID signal`
7	`'BLUE2'  x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...`
8	`'RED1'   x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...`
9	`'END'`

Table 53 shows an example of a CID1 file. From the sample engagement file, there are two BLUE unit types, BLUE1 and BLUE2, and 1 RED unit type, RED1. The first subsection in the sample CID1 file is for BLUE1 as a CID1 host. The first section shows that BLUE2 has a 0.99 probability of CIDing BLUE1 at 500 m. and that probability drops to 0.20 at 3500 m. The next section describes BLUE2 and RED1's probabilities of detecting BLUE1's CID1 signal every 30 seconds. So if RED1 were 2000 m. away from BLUE1, RED1 would have a 3 percent chance of detecting BLUE1 every 30 seconds. BLUE2 has a 10 percent chance of detecting BLUE1 (and thus identifying BLUE1 as friendly) every 30 seconds.

If an observer from BLUE2 detects BLUE1's CID1 signal, he automatically CIDs BLUE1 as friendly.

The second subsection in the table shows the probabilities when BLUE2 has a CID1 type system on board. Again the probabilities are given for correct CID and for detection of the CID signal. There is no subsection for RED1 because RED1 does not have a CID1 on board in this battle.

Table 52: **Combat Identification File 1 Input Definitions**

LINE	VARIABLE	DEFINITION
2	CID Host Unit	Unit name of system carrying CID device
	Det Check Time	Time (sec) between CID detection attempts
4	ObsCID	Observer Unit Name (friendly systems of Host Unit)
	P(CID)	Probability (by range) of this friendly unit CIDing the host vehicle
:	:	
5	END	Ends this section
7	ObsDet	Observer Unit Name (friendly and enemy unit types able to detect Host Unit because of its CID signal)
	P(CDet)	Probability (by range) of this unit detecting the host vehicle's CID signal. These probabilities are based on the time specified on line 2 above.
:	:	
9	END	Ends this section

Table 53: **Combat Identification File 1 - Sample**

```
** Ranges: 500, 1000, 1500, ...
--CID Host Name,  Time for Detection Check
 'BLUE1'                 30.
  -- Probability of these observers CIDing host vehicle
     'BLUE2'  0.99 0.98 0.90 0.80 0.65 0.40 0.20 0.00
     'END'
  -- Probability of these observers detecting host vehicle's CID signal
     'BLUE2'  0.50 0.30 0.20 0.10 0.05 0.01 0.00 0.00
     'RED1'   0.30 0.15 0.07 0.03 0.01 0.005 0.00 0.00
--CID Host Name,  Time for Detection Check
 'BLUE2'                 30.
  -- Probability of these observers CIDing host vehicle
     'BLUE1'  0.99 0.98 0.90 0.80 0.65 0.40 0.20 0.00
     'END'
  -- Probability of these observers detecting host vehicle's CID signal
     'BLUE1'  0.50 0.30 0.20 0.10 0.05 0.01 0.00 0.00
     'RED1'   0.30 0.15 0.07 0.03 0.01 0.005 0.00 0.00
     'END'
```

2.12 Combat Identification File 2 - Query-Response

The second type of combat identification device which can be played is a *query-response* type system. This type of CID is used after an observer detects a target and and before the observer fires at it. Just prior to firing at the target, the firer queries the target, and tries to elicit a response from the target. If the target receives the signal and returns a response, the firer will discontinue the firing sequence, disengage the target, and begin looking for new targets.

Associated with this query and response are four probabilities and a time delay. The diagram below illustrates these inputs. P1 is the probability that when the host (observer) queries a target, the signal will reach the target. P3 is the probability that the target's response will get back to the host (observer's) vehicle. P2 and P4 are the probabilities that the target and then the host (observer's) vehicle will correctly interpret the query and response, respectively. The time delay is simply the time from the initial query, to the observer interpreting the response. What the diagram does not show is that when the target sends out its response, there may be some chance that the response will be detected by enemy units, which may then engage that target.

Figure 1: **Combat Identification Type 2 Methodology**

```
                 -------P1-----------> P2
OBSERVER                                        TARGET
               P4 <--------P3-----------
```

The input file for this type of CID is named *cidfil2*. The file is divided into a subsection for each unit type in the battle. The structure of the subsection is shown in Table 54. Table 55 lists the CID2 file input variable definitions.

Table 56 shows a sample CID2 file. BLUE1 has a CID2 type device on board and will query a target one time before engaging it. The time delay associated with its CID varies from 1.0 second at 500 m. to 1.2 seconds at 3500 m., and its probabilities of CID (P1 values) are very high. BLUE1 is only able to CID BLUE2 since there is no entry for RED1. BLUE1 is also able to detect BLUE2 when it responds to a query. If a firer from BLUE1 queries a unit from BLUE2, other observers from BLUE1 have a 0.1 probability of detecting that response at 2000 m.

The same is true when BLUE2 is the host platform. Its time delay also ranges from 1.0 to 1.2 seconds, but it will try to query a target twice before engaging. Its probabilities of CID (P1 values) are a bit lower than BLUE1's.

RED does not have a CID on board, but is able to detect both BLUE1 and BLUE2's CID responses. These probabilities of detection are entered in the last section in the table. For example, when BLUE1 queries BLUE2, RED1 has a probability of detecting that response of 0.2 at 500 m.

Table 54: **Combat Identification File 2 - Structure**

Line	
1	`---CID Host Unit`
2	`Host Name`
3	`x                                        *** Number of CID Attempts`
4	`x.xx x.xx x.xx x.xx ...                  *** CID Time Delay`
5	`x.xx x.xx x.xx x.xx ...                  *** P1`
6	`--- Probability of CID2 Against These Targets`
7	`Target1 Name`
8	`x.xx x.xx x.xx x.xx x.xx ...             *** P2`
9	`x.xx x.xx x.xx x.xx x.xx ...             *** P3`
10	`x.xx x.xx x.xx x.xx x.xx ...             *** P4`
11	`Target2 Name`
12	`x.xx x.xx x.xx x.xx x.xx ...             *** P2`
13	`x.xx x.xx x.xx x.xx x.xx ...             *** P3`
14	`x.xx x.xx x.xx x.xx x.xx ...             *** P4`
15	`'END'`
16	`--- Probability of Detecting These Targets' Responses`
17	`Target1  x.xx x.xx x.xx x.xx x.xx ... *** P(detect)`
18	`'END'`

Table 55: **Combat Identification File 2 Input Definitions**

LINE	VARIABLE	DEFINITION
2	CID Host Unit	Unit name of querying system carrying CID device
3	Num CID Attempts	The number of times this unit will query a target before engaging it. If the firer receives a positive response from any query he will disengage the target, and not query again. If this unit has no CID then the input is 0.
4	CID Time Delay	The time from the initial query to the observer interpreting the response (by range).
5	P1	The probabilities that when the host queries a target, the signal will reach the target (by range).
Next there is a subsection for each unit type to be queried by the CID. Within each subsection the user enters the target unit's name, and P2, P3, and P4. The section must be ended with an 'END' as the target name.		
7	QTarget.Name	Unit name of system type to be queried by the CID.
8	P2	The probabilities that the target will correctly interpret the query (by range).
9	P3	The probability that the target's response will get back to the host vehicle (by range).
10	P4	The probabilities that the host will correctly interpret the response (by range).
The last section defines the chance for the host vehicle to detect a target when it responds to a CID2 query.		
17	RTarget Name	Unit name of system type which responds to a CID2 query.
	P(Cdetect)	Probabilities that the host vehicle will detect RTarget when it responds to a CID2 query (by range).

Table 56: **Combat Identification File 2 - Sample**

```
*** Comment Line(s)
BLUE1
   1                                      *** Number of CID Attempts
   1.0 1.0 1.0 1.1 1.1 1.1 1.2            *** CID Time Delay
   1.0 1.0 1.0 1.0 1.0 1.0 0.85           *** P1
  --- Probability of CID2 Against These Targets
      BLUE2
         1.0 1.0 1.0 1.0 1.0 1.0 1.0      *** P2
         1.0 1.0 1.0 1.0 1.0 1.0 0.85     *** P3
         1.0 1.0 1.0 1.0 1.0 1.0 1.0      *** P4
      'END'
  --- Probability Detecting These Targets' Responses
      BLUE2 0.2 0.2 0.2 0.1 0.1 0.0 0.0   *** P(detect)
      'END'
*** Comment Line(s)
BLUE2
   2                                      *** Number of CID Attempts
   1.0 1.0 1.0 1.1 1.1 1.1 1.2            *** CID Time Delay
   0.5 0.5 0.3 0.3 0.2 0.1 0.0            *** P1
  --- Probability of CID2 Against These Targets
      BLUE1
         1.0 1.0 1.0 1.0 1.0 1.0 1.0      *** P2
         1.0 1.0 1.0 1.0 1.0 1.0 0.85     *** P3
         1.0 1.0 1.0 1.0 1.0 1.0 1.0      *** P4
      'END'
  --- Probability Detecting These Targets' Responses
      'END'
*** Comment Line(s)
RED1
   0                                      *** Number of CID Attempts
   7*0.0                                  *** CID Time Delay
   7*0.0                                  *** P1
  --- Probability of CID2 Against These Targets
      'END'
  --- Probability Detecting These Targets' Responses
      BLUE1 1.0 1.0 1.0 1.0 1.0 1.0 1.0   *** P(detect)
      BLUE2 0.2 0.2 0.2 0.1 0.1 0.0 0.0   *** P(detect)
      'END'
```

2.13 Range-In File

Ranging-in is a process used by gunners to adjust fire on the target. The range-in process lowers accuracy errors for weapon systems with limited fire control, since the gunner must correct for errors associated with target range estimation, system biases, etc. The gunner achieves more accurate fire by adjusting the aimpoint in response to the perceived impact location of the preceding round. If the range-in variable is set to True (T) in the Weapon Description Input File, then this Ranging-In file must be input. Range-in files are named *brng?* or *rrng?* for Blue and Red systems respectively. The "*?*" indicates sequential numbers from 1 to the number of weapons using range-in. For example, if the Blue force has 4 weapon systems, 3 of which are playing range-in, the model will look for *brng1*, *brng2*, and *brng3*.

When a firer is ranging-in, the model does not use the accuracy file and vulnerability fire input for calculating whether the target is hit, and for assessing damage. Instead, it uses the Range-In file input to determine how many bursts need to be fired before ranging-in to the target. The model will schedule the firer to fire that many bursts, and use the probability of kill values in the Range-In file to assess the damage on the last range-in round. If the target is not killed, the firer will then continue to engage the target, with the normal accuracy file and vulnerability file input then used as normal.

Table 57 shows the structure for the Range-In file. The Range-In File input variable definitions are listed in Table 58.

Table 57: **Range-In Input File**

```
'BLUE1'
* SubFir, Min Range, Max attempts
   x.x       xxxx.x        xx
*                    STATIONARY-STATIONARY
* Rng   1    2    3    4    5    6    7    8    9    10
rng1   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng2   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng3   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng4   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng5   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
*                       STATIONARY-MOVING
* Rng   1    2    3    4    5    6    7    8    9    10
rng1   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng2   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng3   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng4   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng5   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
*                       MOVING-STATIONARY
* Rng   1    2    3    4    5    6    7    8    9    10
rng1   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng2   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng3   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng4   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
rng5   x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x  x.x
*
* PK's for final range-in round
*       HD                            FE
*       Mkill  Fkill  MFkill Kkill   Mkill  Fkill  MFkill Kkill
'RED1'
0       x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng2    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng3    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng4    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng5    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng6    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
*
* PK's for final range-in round
*       HD                            FE
*       Mkill  Fkill  MFkill Kkill   Mkill  Fkill  MFkill Kkill
'RED2'
0       x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng2    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng3    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng4    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng5    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
rng6    x.xx   x.xx   x.xx   x.xx    x.xx   x.xx   x.xx   x.xx
*
```

Table 58: **Range-In File Input Definitions**

LINE	VARIABLE	DEFINITION
1	Weapon Name	Weapon name of system. Must match weapon name used in the Unit Input File.
3	SubFir	Subsequent firing time (sec) for range-in attempts.
	Min Range	Minimum range (m) at which ranging-in is needed.
	Max attempts	Maximum number of range-in attempts in an engagement.
Next are input three sets of range-in probability tables, for the firer-target combinations of stationary-stationary, stationary-moving, and moving-stationary.		

Table 59: **Range-In File Input Definitions - Continued (1)**

LINE	VARIABLE	DEFINITION
6-10	Range	Stationary Firer - Stationary Target Conditions. Range (m) from firer to target. The first range should be the value of the range increment input in the Game File. The last range should be equal to or greater than the maximum firing range of the weapon.
	P(rgin)	Probability of ranging-in using one round, two rounds, three rounds, . . . , ten rounds. The probability of ranging-in for the maximum range-in rounds must be equal to 1.0 as for each range they are cumulative probability distributions. During the game, a random number is drawn and the table is accessed to determine the number of range-in rounds needed. The last range-in round will "hit" the target and the impact is assessed using the Range-In PKH tables (see description of lines 29-35). In reality, the last range-in round will impact within a close enough distance to the target to cause the gunner to decide to start firing for effect. Thus, the last round does not always hit the target, but it might.
13-17		Stationary Firer - Moving Target Conditions. (as for 6-10)
20-24		Moving Firer - Stationary Target Conditions. (as for 6-10)
Next, for each target type is input a PKH table to be used for the last range-in round. The PKs are entered as a function of IUA kill type, target exposure, and range.		
29	Vehicle Name	Vehicle name of target.
30-35	Range	Range (m) from firer to target (for Range-In PKH files). The first range should be zero. Increments must be as set in the game file. The last range should be equal to or greater than the maximum firing range of the weapon.
	RI-PKH	Range-in PKH values for M-kill, F-kill, MorF-kill, and K-kill. The first group of four are versus a hull defilade target, the second four are versus a fully exposed target. These values will be converted to M-only, F-only, M&F, K-kill, and no-kill for Groundwars' use.

3 Release Authority

The Groundwars Model is the property of the Federal Government. The model may be released to any government agency which has a use for it. However, release to a government agency does not give authority for that agency to release the model to other agencies or contractors.

Contractors are permitted use of the model if a contract exists with the government which requires its use. Contractors are required to have their government point of contact provide this office with a letter of request. Upon receipt of this request, AMSAA will provide the contractor with a Memorandum of Agreement for the use and modification of the model. Upon execution of this agreement, AMSAA will provide the model to the government POC, who in turn provides it to the contractor.

Any modifications which are made to the model should be provided to this office. Any errors in the model should be addressed to one of the points of contact in the next section. Requests for the model should be sent to:

Director
US Army Materiel Systems Analysis Activity
ATTN: AMXSY-CD (L. Harrington)
Aberdeen Proving Ground, MD 21005-5071

4 Points of Contact

The following list provides points or places of contact for questions pertaining to the Groundwars Model and required input data.

- Groundwars Model:

  Gary Comstock (DSN 298-4090)
  Lilly Harrington (DSN 298-5373)
  Simulation Branch (AMXSY-CD),
  Combat Integration Division,
  AMSAA

- Vulnerability Data:

  Ballistic Vulnerability/Lethality Division (BVLD)
  Survivability/Lethality Analysis Directorate (SLAD)
  Army Research Laboratory (ARL)
  Aberdeen Proving Ground, MD

- Terrain Data:

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SUBJECT: Technical Report xxx, Groundwars 5.3 User's Guide

PRINCIPAL FINDINGS: NA

MAIN ASSUMPTIONS: NA

PRINCIPAL LIMITATIONS: NA

SCOPE OF THE EFFORT: Groundwars Combat Simulation. Ground to ground combat simulation of a two-sided battle between heterogeneous forces.

OBJECTIVE: To document the input requirements of the model and to inform the user of the requirements and capabilities of the model.

BASIC APPROACH: The simulation is based on Monte Carlo probability theory. It is event-sequenced with critical ground battle events being modeled.

REASON FOR PERFORMING THE EFFORT: To document the input requirements of the model for user execution.

IMPACT OF THE EFFORT: NA

SPONSOR: U.S. Army Materiel Systems Analysis Activity

PRINCIPAL INVESTIGATOR: Gary R. Comstock

COMMENTS AND QUESTIONS:
AMXSY-CD (Attn: G. Comstock)
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DEFENSE TECHNICAL INFORMATION CENTER (DTIC) ACCESSION NUMBER OF FINAL REPORT: Report available by contacting AMSAA's Reports Processing Center, DSN 298-5676

WHO COULD BENEFIT FROM THIS REPORT: Within-house and outside government agencies who use the Groundwars model to conduct weapon system analyses. Also, defense contractors who use the model need this report to format input data.